JOURNAL OF THE A·I·E·E·

DECEMBER 1928

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PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

MEETINGS

of the

American Institute of Electrical Engineers

WINTER CONVENTION, New York, N. Y., January 28-February 1, 1929

REGIONAL MEETING, Middle Eastern District No. 2, Cincinnati, Ohio, March 20-22, 1929

REGIONAL MEETING, South West District No. 7, Dallas, Texas, May 7-9, 1929

SUMMER CONVENTION, Swampscott, Mass., June 24-28, 1929

PACIFIC COAST CONVENTION, Los Angeles, Calif., September 3-6, 1929

REGIONAL MEETING, Great Lakes District No. 5, Chicago, Illinois, December 2-4, 1929

MEETINGS OF OTHER SOCIETIES

The American Society of Mechanical Engineers, Annual Meeting, Engineering Societies Building, New York, N. Y., December 3-7, 1928

American Society of Agricultural Engineers, Technical Divisions, Hotel Sherman, Chicago, Illinois (Raymond Olney, Sec'y., St. Joseph, Michigan), December 4-7, 1928

The American Society of Civil Engineers, Annual Meeting, Engineering Societies Building, New York, N. Y., January 16-18, 1929

The American Institute of Mining and Metallurgical Engineers, Annual Meeting, Engineering Societies Building, New York, N. Y., February 18-21, 1929

JOURNAL

OF THE

American Institute of Electrical Engineers

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33 West 39th Street, New York

PUBLICATION COMMITTEE

W. H. Gorsuch, *Chairman*, H. P. Charlesworth, F. L. Hutchinson, Donald McNicol, E. B. Meyer

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Electric Light and Power Rates in the United States, Sept. 1928

Layout of a Hypothetical Substation, October 1928

THIS issue of the JOURNAL reaches the members just before the holiday season. It is thus a suitable messenger to carry to all of you the greetings and best wishes of your officers.

We have every reason to feel a sincere pride in the progress and accomplishments of the Institute. It enters its forty-fifth New Year conscious of an outstanding position as an organization for service, for holding high the ideals of the profession, for furthering the advance of engineers and engineering, and for giving guidance and inspiration to the embryo engineers in our schools and colleges.

A very Merry Christmas and a Happy New Year to all

A Profitable Meeting

RECENTLY your president had the privilege of attending an Institute meeting which for interest and profit was unusually successful. It was a joint meeting of a section and a student branch. The attendance was made up of students, faculty members and practising engineers in approximately equal proportion. It was no formal address that brought together this interested group but a symposium in which students, faculty and practising engineers all took part.

The students told the meeting how the industrial world looked through their eyes and what they hoped awaited them when they stepped out into that world. They were in turn told by engineers prominent in their respective fields what some of the rules of the game are and how to interpret the sign posts along the road. The faculty members with their great responsibility both ways entered into the discussion with enthusiasm and expressed thoughts of value to the students and to the practitioners. Incidentally the discussion brought out the fact that opportunities are constantly at hand for the engineer to be of unusual service to his city and that by accepting these opportunities, which more properly are obligations, he is helping to enhance the standing of the profession.

The students, who reflected their public speaking training splendidly, laid emphasis on their desire and need for more contact with practising engineers, such, for example, as was offered by this meeting. The practitioners on their part found inspiration in the contact with ambitious and studious youth. The meeting reawakened in them appreciation of the fact that they have a very deep interest in the guidance of the men who are preparing to be their assistants and later their successors.

Some joint meetings attempted in the past and having a technical talk for the program failed to draw the students. For them it was but another lecture. With a student-only program the practising engineers failed to show interest. The combination student and practitioner program was the feature that attracted well over a hundred to this meeting.

There are other localities where sections and student branches are within easy travel distance of each other. Our members in those localities may feel it worth while to give the holding of such a joint meeting earnest consideration.

R. F. Schuchardt

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Vol. XLVII DECEMBER, 1928 Number 12

Report of Committee on Power Generation

This committee gave a complete and comprehensive résumé last year of the progress made and the trend in the art of power generation. Many of the important features of that report still describe the present practise in the various branches of power station development, and for this reason it was thought inadvisable to attempt a similar undertaking so soon thereafter. Some interesting material however, has already been collected and will be included in next year's report.

The principal activity of the committee this year has been the planning and preparation for the session on "Interconnection and its Effect on Power Development," held at the Winter Convention in New York on Tuesday, February 14th, 1928. A most interesting and valuable group of papers was presented which, with the additional information and ideas given in the prepared discussion, constitutes a comprehensive symposium on present-day practise and new developments of interconnection in various parts of the United States. Some of the features included in the papers and discussion are,—Effect on Plant Capacity and Size of Generating Units; Economics of Operation; Various Operating Features; Stability and Reliability; Load Dispatching and Load Control; Technique of Interconnection Operation and Physical Facts as to Interstate Power. The papers presented are as follows:

The Conowingo-Hydroelectric Project of the Philadelphia Electric Company's System—With Particular Reference to Interconnection, W. C. L. Eglin, The Philadelphia Electric Co. This paper was completed and presented by Mr. N. E. Funk because of the untimely death of Mr. Eglin.

Progress and Problems from Interconnection in the Southeastern States, W. E. Mitchell, Georgia Power Co.

Some Aspects of Pacific Coast Interconnection, P. M. Downing, Pacific Gas and Electric Co. This paper was presented by Mr. J. C. Parker, Brooklyn Edison Co.

Interconnection and Power Development in Chicago and the Middlewest, H. B. Gear, Commonwealth Edison Co.

In addition to the above papers, prepared discussions were given by the following members; Charles L. Edgar, Edison Electric Illuminating Company of Boston; A. C. Marshall, The Detroit Edison Co.; James Lyman, Sargent & Lundy, Inc.; Farley Osgood, Consulting Engineer; E. C. Stone, Duquesne Light Co.; L. W. W. Morrow, *Electrical World;* W. S. Lee, Southern Power Co.; C. F. Hirshfeld, Detroit Edison Co. and F. A. Allner, Pennsylvania Water & Power Co.

This symposium on Interconnection should be the means of indicating profitable lines for further study of this timely subject. With the extension of transmission lines, the increasing development of hydroelectric projects and the unprecedented capacities of power stations together with the ever widening areas over which electric energy is being used, the interconnection and coordination of various power systems is a matter that is becoming increasingly important. Many problems will arise from the greater complexity and magnitude of the interconnections, which should be presented and discussed in detail. This will be a fertile field to be cultivated by the Institute and particularly by the Power Generation Committee.

The work assigned to the sub-committee on standards in connection with "Measuring the Output of a Generator," has been completed, approved by the Standards Committee and forwarded to the A. S. M. E., for inclusion in its Test Code for Steam Turbines.

A subcommittee has been assigned to the task of reviewing the existing standards on Prime Movers-Generator Units, for the purpose of seeing what modifications if any, should be made, and also to propose any new standards for this equipment.

The Committee on Power Generation would stress the importance of standardization and recommends that its members render all possible assistance in proposing and developing new standards of such subjects as properly come within its scope.

Other activities of the Committee on Power Generation have included the assistance given the Meetings and Papers Committee in securing and selecting papers for the Institute Conventions, and also in reviewing papers for the purpose of awarding prizes.

WM. S. GORSUCH, *Chairman,*
Committee on Power Generation.

Some Leaders of the A. I. E. E.

SAMUEL REBER, retired colonel, U. S. A., Vice-President of the Institute 1904-1906 and one of its Managers for the preceding period 1901-1904, was born in St. Louis, Missouri. He was graduated from West Point Military Academy in 1886, received an appointment as Second Lieutenant of the Fourth Cavalry, was promoted to First Lieutenant and, in 1894, was transferred to the Signal Corps. It was also in 1894 that he was graduated

from an electrical engineering course at Johns Hopkins.

At the outbreak of the Spanish-American War, he was commissioned a major in the Volunteer Signal Corps and was subsequently promoted to lieutenant-colonel and Chief Signal Officer. At the close of the war, he received his honorable discharge from the Volunteer Service and in July 1900 was commissioned Captain in the Signal Corp, promoted to major in 1903, to Lieutenant-Colonel in 1913 and to Colonel in 1916.

In 1905 he completed the course in the Army War College, at Washington,—the highest course of study in the American Army. While in France during the World War, he was graduated from the A. E. F. General Staff College at Langres. Upon his return from France November 1919, Colonel Reber retired from active military service and since that time has devoted himself to an active service in civil life, engaging with the Radio Corporation of America in 1923, and at present its special foreign representative.

During his career in active Army service, Colonel Reber participated in the campaign against hostile Indians in Arizona, served through the Porto Rican campaign, and subsequently with the Army of Occupation in Cuba, where he was in charge of the telegraph and telephone systems of the island. He then served as Military Secretary to the Commanding General of the Army until the abolishment of that grade and the establishment of the General Staff, of which he became a member of the First Detail of that organization and the first Secretary of the Army War College. On the completion of his detail with the General Staff he served as Chief Signal Officer of a number of Military Departments and the Division of the Philippines, where he transferred the cable and telegraph system to the civil government. During the World War he served in France as Provost Marshal of the Service of Supplies, with the 28th and 88th Divisions, and as D. C-O-S. of the Second Army. He was gassed in action at Haumont. After the armistice, while in command of the Intermediate Section and Base Sections 4 and 6, he effected the transfer of the American Army supplies and property to the French authorities and repatriated the American forces in those sections.

For a number of years he was in charge of the design and development of the electrical apparatus of the Signal Corps, superintended the manufacture of the submarine cable for the Philippine Islands and was instrumental in the formation of the committee which prepared the standard specifications for 30 per cent rubber insulation adopted by the Institute. Assisted by Doctor Carl Kinsley, in 1900 he developed the first American system of radiotelegraphy. This system was installed and operated under commercial conditions both in New York and San Francisco harbors; in the latter place, it replaced the cable between Fort Mason and Alcatraz Island. In 1915 he was associated with General. J. J. Carty in the development of the successful long distance radio telephone tests.

He is a licensed balloon pilot and has had extensive experience in ballooning and aviation, having, as Chairman of the Contest Committee of the Aero Club of America, supervised nearly all the international aviation meets held in the United States and was in charge of the Aviation Section of the Signal Corps of the Army in 1913-16, and a member of the National Advisory Committee for Aeronautics.

Colonel Reber was admitted as an Associate of the Institute in September 1923; he was elected a Fellow in 1912; and has served on the following Institute committees: Membership Committee, 1902-4; Advisory Committee on Building Fund, 1903-4; Edison Medal Committee, 1905 to 1911; Telegraphy and Telephony Committee, 1909-10; Meetings and Papers Committee, 1910-11; Telegraphy and Telephony Committee, 1910-11 (Chairman); Additional Grade of Membership Committee 1911-12; Code of Ethics Committee, 1911-12.

He was secretary of Section B of the International Electric Congress in 1893; a member of the Electrical Juries in the Chicago and Saint Louis Expositions in 1893 and 1904; the War Department delegate to the International Electrical Congress of 1904, and a delegate to the following international conferences: Telegraph, at Paris in 1925; Radiotelegraph, at Washington 1927; Telegraph, at Brussels in 1928, and the Third Juridical Congress on T. S. F. at Rome, 1928.

He is an Officier de l'Etoile Noire, a recipient of the Fourth Order of the Rising Sun, a Fellow of the Institute of Radio Engineers, a member of the Franklin Institute and of the National Institute of Social Sciences; and the author of a number of technical papers and books.

Factory lighting and ventilation should be supervised by the state through a licensing system. This is a recommendation of Dr. George M. Price, director of the joint board of sanitary control in the women's garment trades, and was called forth because of poor lighting and ventilation in the six thousand garment factories in New York. In 1913 a report showed that nearly 75 per cent of garment workers had defective eyesight, and, in the opinion of Dr. Price, the percentage is nearly as high at present. Not more than 5 per cent of these factories have sufficient daylight for the workers. These conditions are inexcusable, for lighting as an art has been developed so that any industry at very small cost can have abundant light of the right quality.

It would appear that the electrical industry has not educated the garment trades. State intervention in a common-sense situation where production alone makes good lighting economical is a remedy to be applied as a last resort.—*Electrical World.*

Abridgment

Hot Cathode Neon Arcs

BY CLIFTON G. FOUND[1] Non-member and J. D. FORNEY[2] Non-member

Introduction

IN a discharge tube containing cold electrodes there is a very high-voltage drop at the cathode. Positive ions falling through this drop result in the emission of a small primary electron current which maintains the discharge by ionization by collision. Thus, we see that the function of the high cathode drop is the production of this primary electron current.

When a hot cathode with a thermal electron emission sufficient to supply the current through the tube is substituted for the cold electrode, there is no longer any necessity for the high-voltage drop at the cathode as we already have plenty of primary electrons. All that is needed is a voltage sufficient to cause ionization of the gas. This voltage is never greater than 25 volts. Thus, the substitution of a hot cathode reduces the cathode drop to a few volts and we avoid all the difficulties caused by the high cathode fall in a cold cathode discharge. In other words, the replacement of the cold electrode by a hot electron-emitting one causes the discharge to pass from a glow to an arc, as defined by K. T. Compton.[3] His definition states: "An arc is a discharge of electricity between electrodes in a gas or vapor which has a negative or practically zero volt-ampere characteristic and a voltage drop at the cathode of the order of the minimum ionizing or minimum exciting potential of the gas or vapor." By an adjustment of the pressure, the region of cathode glow and Faraday dark space can be greatly reduced, so that the main portion of the tube is filled with the luminous positive column.

Construction of Hot Cathode Arcs

In the previous paper, Doctor Hull has described the construction of a cathode capable of supplying very large currents. This type of cathode has been used in the construction of the neon tubes to be described in the remainder of the paper. A further description of this cathode seems unnecessary. The radiation type of cathode has a decided advantage over a filamentary cathode in the fact that large areas can be obtained without using excessive heating currents, as in the case of heavy filaments, and also without having a large voltage drop between the terminals as in the case of a long filament. In the latter case, if the voltage across the filament is much greater than the ionization voltage of the gas used, an arc is formed across the leads and the filament is burned out.

The construction of a hot cathode neon tube is shown in Fig. 1. It consists of an elongated tube on one end of which is a cathode of the type mentioned, which is capable of giving an electron current of about 3.5 amperes when the heater is taking 60 watts. At the opposite end is an iron electrode which serves as anode. The pressure of neon in the tube is about 2 mm. of mercury. At this pressure, practically all of the tube is filled with positive column.

Electrical Characteristics of Discharge

Before mentioning the characteristics of the tube as a unit we should like to discuss some characteristics of the discharge within the tube. Using the exploring electrode method, measurements of the potential distribution in a hot cathode neon tube show a cathode drop of about 25 volts, followed by a uniform gradient throughout the tube. The drop at the anode varies from a few volts positive to a few volts negative, but is never very different from zero.

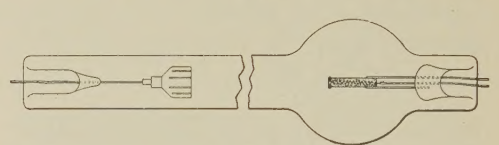

Fig. 1

Potential Gradient as a Function of Pressure, Current, and Tube Diameter

1. Pressure. Measurements of the potential gradient as a function of the pressure show a flat minimum at from 2 to 5 mm. pressure as shown in Table I.

TABLE I

Discharge current = 2.0 amperes

Pressure	Gradient
0.2 mm.	1.95 volts/cm.
0.6	1.90
1.5	1.72
2.3	1.65
3.1	1.65
4.25	1.61
4.9	1.80

2. Discharge Current. The voltage-current relation in the main portion of the discharge is shown in Table II. The voltage gradient decreases as the current increases, giving a negative "resistance" to the discharge.

1. Research Lab., General Electric Co., Schenectady, N. Y.
2. Cooper-Hewitt Electric Co., Hoboken, N. J.
3. K. T. Compton, A. I. E. E. Trans., Vol. XLVI, 1927, p. 868.

Presented at the Joint Meeting of the New York Sections of the A. I. E. E. and the I. E. S., May 18, 1928. Complete copies upon request.

TABLE II

Pressure = 0.2 mm. mercury

Current amps.	Gradient volts per cm.
0.5	2.1
1.0	2.0
2.0	1.95
3.8	1.87
6.8	1.78

3. Tube Diameter. Table III shows the relation between tube diameter and potential gradient.

TABLE III

Tube diameter	1.29 cm.	1.95 cm.	2.55 cm.
Gradient	3.36 volts/cm.	2.15 volts/cm.	1.75 volts/cm.
Product	4.20	4.17	4.45

This result is in accord with the theory of Shottky,[4] who, from theoretical considerations on the rates of diffusion of ions and electrons to the walls, has deduced that the voltage gradient should vary inversely as the tube diameter. Results of Claude[5] on tubes filled with

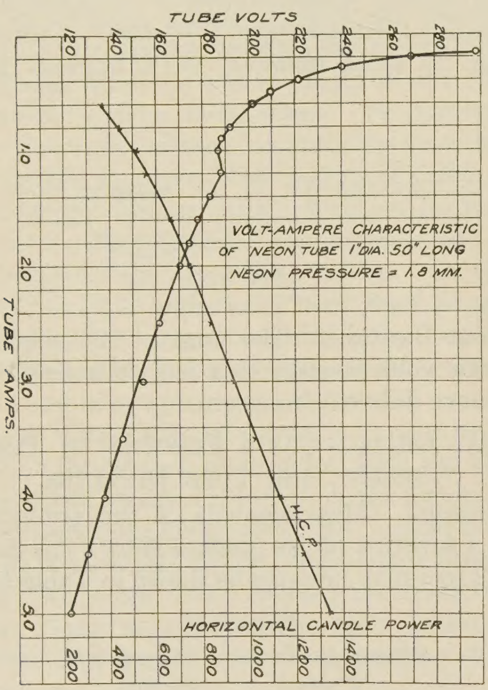

Fig. 2

neon at a pressure of 2 mm. are also in agreement with Shottky's equation.

Operating Characteristics

The over-all voltage-current relation for a tube 125 cm. long and 2.2 cm. in diameter is shown in Fig. 2. On account of the negative "resistance" characteristic of the tube, the latter is inherently unstable and requires a resistance in series for stable operation. The value of this resistance must be greater than the resistance corresponding to the slope of the volt-ampere curve or the tube will not operate. It will be noted that for low currents, much greater series resistance is required, and also the change in slope is greater at low current values. Therefore, for most stable operation, it is desirable to operate at a current where the change in slope is least, as at this point a larger proportion of the available voltage can be utilized in the tube. Also, an inductance in series with the arc eliminates transients and permits steadier operation.

Starting of Tubes

On a tube in which the distance from the walls to

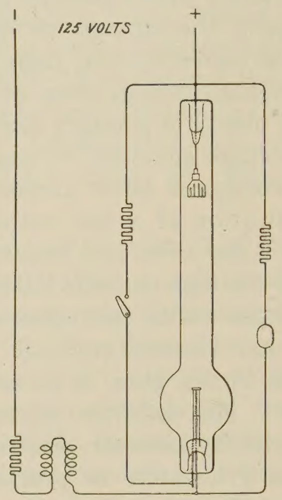

Fig. 3

the cathode is small compared to that between electrodes, the walls of the tube become negatively charged and it is necessary to remove this charge before a discharge will pass. This is true in the present tubes and there are three methods by which the tubes may be started.

1. A high-frequency discharge may be brought close to the tube.

2. An auxiliary anode may be placed sufficiently close to the cathode for a discharge to take place to it. This produces ionization in the tube, which neutralizes the charge on the walls and by connecting the auxiliary and main anodes together through a suitable resistance the discharge can be transferred to the main anode.

3. By suddenly stopping the current in an inductance in series with the discharge, a high inductive kick which causes enough ionization in the gas to allow current to pass is produced in the main circuit. This type of starting device is used in the Cooper-Hewitt mercury vapor lamps and is the method employed for the tubes described below.

Types of Tubes

1. *D-c. Tubes.* The circuit for a d-c. tube with stabilizing resistance and series inductance is shown in Fig. 3. Here the heater wire is so chosen that it requires the same current as the discharge. After

4. Shottky, *Phys. Zeit.*, XXV, 342, 635 (1924).

5. Claude, *Comptes Rendus*, p. 479, 158 (1914).

the cathode is heated by means of the auxiliary circuit, the latter is opened and the discharge, which has been started by an inductive kick as described in the third method of starting, passes through the heater, which now takes the place of part of the stabilizing resistance. This is a decided improvement over a Geissler discharge form of tube, since the latter can be operated

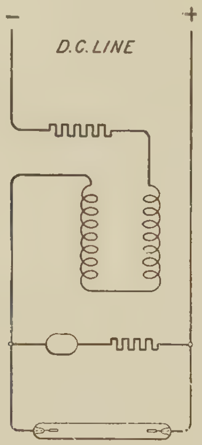

Fig. 4

on a d-c. source of voltage only by using a special high-voltage generator. A hot cathode tube of this type, 2.2 cm. in diameter and 75 cm. long, may be operated from a 125-volt d-c. line.

When both a-c. and d-c. voltages are available, the

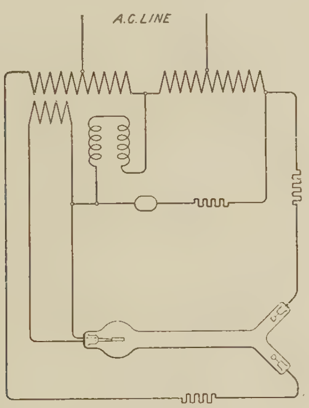

Fig. 5

heater unit may be operated from the a-c. supply, while the arc itself may be run on direct current. The d-c. circuit for this tube, including the circuit for the method of starting by the inductive kick, is shown in Fig. 4. When the voltage is applied, the tube is shunted by a mercury switch and a resistance which limits the current in this circuit to about one ampere. As soon as this current energizes the inductance the magnetic field from the coil tips the switch, breaking the auxiliary circuit very quickly (in less than 1/5000 of a second). This gives an inductive kick of about 2000 volts across the tubes.

2. *A-c. Tubes.* An a-c. tube is made with an anode in each of two short arms at the opposite end of the tube to the cathode. This tube, with its electrical connections, is shown in Fig. 5. The cathode is connected to the midpoint of an auto-transformer through a reactance. Each terminal of the transformer is connected to an anode through a small resistance. This arrangement permits a uni-direction current to pass through the tube. The reactance causes a lag in the current so that the two half waves overlap. This

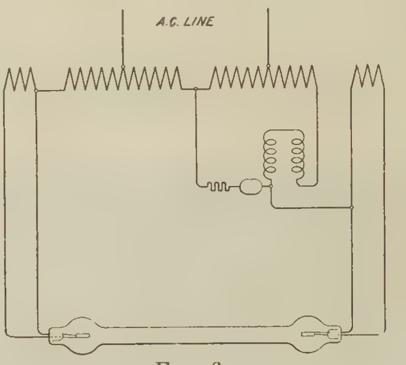

Fig. 6

reduces the current to an almost constant value and there is no visible flicker in the lamp.

Another type of a-c. tube with connections is shown in Fig. 6. A hot electrode is placed at either end of the tube and operates as cathode on one-half cycle and

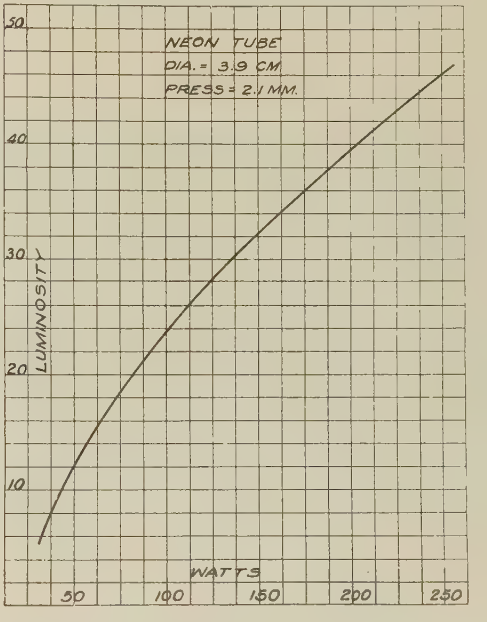

Fig. 7

anode on the other. A large reactance in series with the tube is necessary to eliminate flicker.

Luminous Characteristics

Photometric measurements of a neon lamp show that as a first approximation the luminosity varies as the $\frac{2}{3}$ power of the current, but owing to the negative volt-ampere characteristic, the light emitted is practi-

cally proportional to the watts at higher currents, as shown in Fig. 7. These measurements apply to the positive column only. Measurements of entire tubes show an over-all efficiency of 12 to 15 lumens per watt for d-c. tubes and 10 to 12 lumens per watt for a-c., which is about the same as the 100-watt size Mazda C lamp.

A 220-volt tube, which is 2.2 cm. in diameter and 125 cm. long, operating at three amperes, has a luminous output of about 10,000 lumens.

Life

Tubes have been operated on life tests and many have run over 3500 hr. At the end of this period there

Fig. 8

was practically no discoloration of the walls and no measurable change in the volt-ampere characteristics of the tube. Also, from the general appearance of the electrodes, it does not appear too optimistic to predict a life of 5000 hr. or more.

A feature of the tube is that its operation is independent of the surrounding temperature. Tubes have been successfully operated, without attention, exposed to all kinds of weather—rain, sleet, snow,—and at temperatures as low as − 20 deg. cent.

Uses of Neon Lamps

Display and Advertising. The color of the light emitted by neon makes it attractive for display and advertising purposes. D. McFarlane Moore did a great deal of pioneer work in the use of gaseous discharges in nitrogen and carbon dioxide for sign work. These were of the cold cathode type. The hot cathode neon discharge is especially adaptable for display where high intrinsic brilliancy is required.

White Light and Photography. A neon lamp used in combination with a Cooper-Hewitt mercury lamp supplies the red which is missing in the latter, and by adjusting the mixture of the two, a good approximation to white light can be obtained. This can be observed in Fig. 8, which shows a spectrum of mercury at the top, neon in the middle, and one of skylight at the bottom.

The mercury-neon combination is particularly adapted to panchromatic photography. To obtain the correct reproduction with daylight and panchromatic films, it is necessary to use an amber filter, as the films are more sensitive in the blue than the red. By adjusting the mixture of neon with Cooper-Hewitt mercury lights, the illumination may be made to correct for the sensitivity of the film and a filter is no longer necessary.

Fog Penetration

In heavy or foggy weather, transportation, especially boats and aircraft, is at a great disadvantage. Measurements made by Mr. Frank Benford[6] show that the absorption of the longer wavelengths in thick weather is less than that of the shorter ones. Also, general experience indicates that red can be more easily discerned than other colors. This is due not only to the fact that it has less absorption but also to its contrast with surroundings. In a fog, a great deal of the shorter wavelengths are scattered, giving rise to the glare with which every motorist is familiar. Similarly, when one is looking for a light, this scattered light forms a sort of illuminated blanket, which diminishes the contrast between the light source and its surroundings. When a red light is used, the scattered light is minimum, thus making it easier to observe the source.

Since the hot-cathode neon lamp is one of relatively

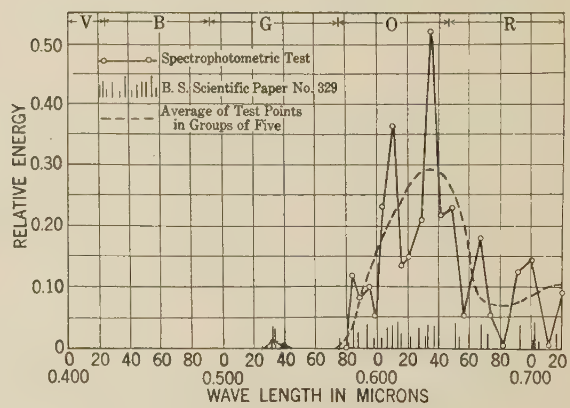

Fig. 9—Spectrophotometric Test

Neon tube No. 18.004 at 2 mm. pressure, 4.0 amperes, 121.5 volts

high intrinsic brilliancy, it is especially adapted for this purpose as its maximum energy occurs at about 6300 A°. We are indebted to Mr. Benford for the spectrophotometric analysis given in Fig. 9.

As a test on the advantages of the hot-cathode neon tube in weather of low visibility, a light of this type was mounted on a pier in the Hudson River. Observations from boats during a fog have shown that it was possible to pick up the red neon light before any of the other lights in the same vicinity were observed. These results indicate that this type of tube will be of great assistance as a marker for docks and ferry slips in the

6. Frank Benford, *General Electric Review*, Oct. 1926.

harbors and if placed on a ship, it would also afford protection against collision with other vessels.

The same properties make it desirable in aviation. Its possible uses in this field include outlining a landing field, marking obstructions and indicating a run-way. Highly concentrated tubes have been constructed for use in beacons and searchlights where a high-intensity beam is required.

In general, we believe that the hot cathode neon arc is the most efficient high-intensity source of red light we have at present.

In conclusion, the authors wish to acknowledge indebtedness to their co-workers for the great assistance which they have rendered, and especially to Doctor Saul Dushman, whose interest and suggestions have been of material help in the development of these tubes.

Abridgment of

A Study of High-Voltage Flashovers

BY JOSEPH T. LUSIGNAN, Jr.[1]

Associate, A. I. E. E.

Synopsis.—A brief discussion is given of the various forms of electrical discharges as they are characterized by the physicists.

Oscillographic records secured of voltages and currents, both before and during the flashovers, are reproduced and discussed. Polarity tests, in which the electrode shape and spacing were found to determine the sign of the half-cycle at which flashovers would start, are described.

Photographic results obtained with moving films are illustrated, showing the various stages of a flashover from the formation of the corona discharges through the initial sparkover to the development of the half-cycle arc channels. The flashovers studied ranged from several feet to 22 ft. in length.

Spectrographic analyses of the different stages of a flashover are described, wherein it is possible to gain some knowledge of several factors contributing to the conductivities of the various stages. Several of the spectra obtained are illustrated and a comparison spectrum of lightning is given.

With the knowledge gained from the laboratory studies the probable history of a high-voltage a-c. flashover is summarized.

* * * * *

Introduction

The object of the study here described was to secure a better understanding of the development of a high-voltage a-c. flashover, particularly with a view to investigating the successive stages of discharge involved, and the various factors contributing to their existence,—from the initial localized breakdown of air or corona to the final stage of a fully developed power arc. The entire experimental work was carried out in the Harris J. Ryan High-Voltage Laboratory at Stanford University.

Oscillographic Study of Flashovers

Voltage and Current Waves. Fig. 1 shows the voltage wave of the initial part of a 20-ft. flashover, the formation point of the arc being on the half cycle where the sharp drop in voltage occurs. Each half cycle after that is seen to start with a brief rise in voltage which breaks down the gap again and allows the arc to re-form, whereupon the voltage drops for the remainder of the half cycle. If the potential applied to the electrodes is allowed to decrease after the arc forms, then the latter may break of its own accord. Fig. 2 shows the corresponding voltage wave of the final stage of such an arc. The record represents two revolutions of the film and starts at a on the irregular wave of the arc itself. Here again it is apparent how each half cycle starts with a brief rise in voltage which each time breaks down the gap, but as the record progresses, and the current decreases due to the applied voltage being allowed to fall, the voltage

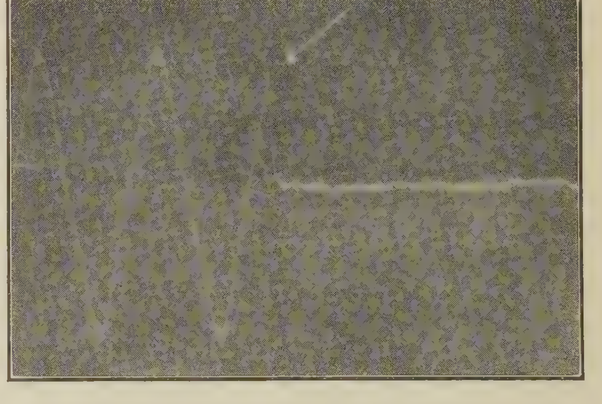

Fig. 1—Voltage Wave at Start of 60-Cycle Flashover

Arrow indicates point of breakdown

has an increasingly harder task to maintain the half cycle discharges so that the initial half-cycle voltage needles continue to increase in magnitude. Finally at the point b the voltage is no longer able to re-form the arc for that half cycle and the regular open-circuit voltage wave starts, which continues around on the film a second time and drops to zero at c when the circuit breaker opens.

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One of the corona current records obtained is shown in Fig. 3. The current wave is seen to be decidedly unsymmetrical with respect to the halves of each cycle, indicating the rectifying effect that is always associated with a point in corona. On the positive current crests a series of discharge needles may be detected whereas on each of the negative crests usually

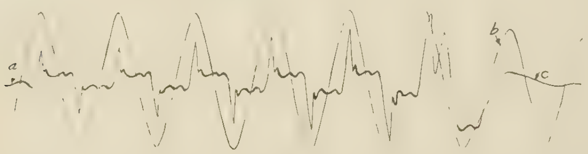


FIG. 2—VOLTAGE WAVE AT END OF 60-CYCLE FLASHOVER

Arc broke due to lowering of applied voltage

but one appears. Current waves taken as the voltage across the 20-ft. gap is slowly increased from pre-corona values show that the positive current needles appear soon after corona starts and occur regularly on the positive half cycles. The negative half cycles of current increase in magnitude as the voltage rises, but the brief discharge needles do not appear until almost to the point of flashover, when they usually occur but once on a crest. Later this feature will be seen to check well with photographic observations taken on moving films.

Determination of Flashover Polarities. As an added step in the study of flashover characteristics, tests were made to investigate the polarities at which dif-

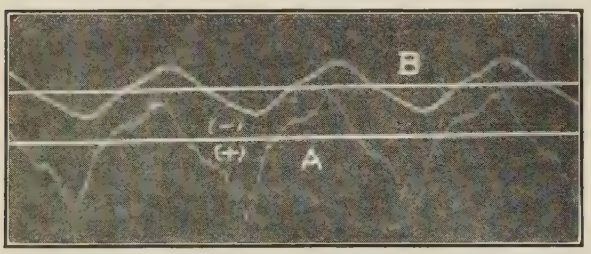


FIG. 3—CORONA CURRENT PRIOR TO FLASHOVER

A. Corona current wave prior to flashover of 20-ft. point-gap
B. Corresponding voltage wave

ferent gaps would arc over to ground at 60 cycles, and in that way, ascertain whether this phase of a flashover took place in any orderly manner. With direct current, the point-to-plane set-up has always been found to arc-over at a lower potential when the point was positive than when it was negative, except at small spacings of the order of a fraction of an inch[2] and therefore this arrangement was tried first to see whether the same was true for alternating voltages. About 50 flashovers were taken with spacings ranging from 5 to 10 ft., and oscillographic records of the current in each case were secured in the ground end of the high-voltage winding. In every instance the flashover started on the half cycle when the point was positive.

A similar test was made on 50-cm. spheres with the bottom sphere grounded. With the spheres spaced 50 cm. apart, approximately 50 flashovers were taken, and found to start with the ungrounded sphere negative, which was just opposite from the results with the point-to-plane set-up. The sphere-gap was next opened up to a maximum spacing of 69 cm., and the arc-overs were found to start on both halves of the waves, that is, the spheres flashed over from the upper sphere on either the positive or negative crests.

From the above results it seemed that initial local breakdowns due to concentrated field intensities would cause a flashover to start positively from the ungrounded electrode, while, on the other hand, with a more or less uniform field, such as a sphere-gap at close

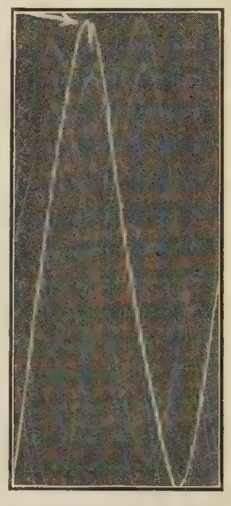


FIG. 4—VOLTAGE WAVE JUST PRIOR TO FLASHOVER OF 18-FT. POINT-GAP

Arrow indicates brief drop in voltage at wave crest due to transient sparkover, one cycle before start of flashover

spacing, the arc to ground would form on the negative crest of the wave.

Sixty-cycle polarity tests were also made on shielded and non-shielded suspension insulator strings of 10 and 14 units, respectively, where it was found that practically all flashovers to ground started on the conductor positive crests. Occasionally one would take place on a negative crest, but the average was never more than about one out of every 25 discharges. These results would seem to fit in well with d-c. and impulse insulator flashover tests made by Peek[3,4] in which he found the arcs to form on lower positive potentials than negative.

PHOTOGRAPHIC STUDIES OF FLASHOVERS

For the purpose of securing possible photographic analyses of flashovers, a special camera with a revolving film holder was made. By driving the cylinder at different speeds, it was possible to draw out the dis-

2. See bibliography for references.

charge figures on the films as much as desired; and by the use of shutters actuated by relays, the films could be exposed to any phase of a flashover.

Figs. 5 and 6 show some of the moving film records obtained in this manner. In each of the figures it is apparent how the path of the first breakdown, shown by the brief but heavy discharge at the start of the first half cycle, practically determines the path of the succeeding half cycles.

The manner in which the streaks of light are drawn out on the film after the last half cycle of arc proved of interest. They can be accounted for, undoubtedly, in the following manner: The arc itself is probably not more than a fraction of a millimeter in thickness, but at the points where it is folded or bent, there are several millimeters or more of arc length in the line of vision. Therefore, at these folded points there will be much stronger light intensities which will have greater effects on the photographic film. The ionized gas remains partly incandescent even between half cycles

Fig. 5—Reproduction of Moving-Film Photograph of 10-Ft. Horizontal Flashover of 11 Half Cycles Duration Between Pointed Electrodes

when the current is passing through zero, which densimeter measurements verified; but it is only the more intense folds of the arc that appear to persist on the film between half cycle bands. Accordingly, after the last half cycle, it is these same folds that streak out as if by themselves. Undoubtedly the whole path across the gap remains incandescent, but only those parts that are bent to appreciable length in the line of vision seem to show up on the film, those of the greatest depth lasting longest. In some of the films obtained, these folds persisted as long as three cycles after the arc-overs had ceased, indicating that the gas in the gap remained incandescent that long.

In the first work with the 10-ft. horizontal point-gap, with both sides insulated, it was noticed that the brush discharges from each point prior to arc-over were only

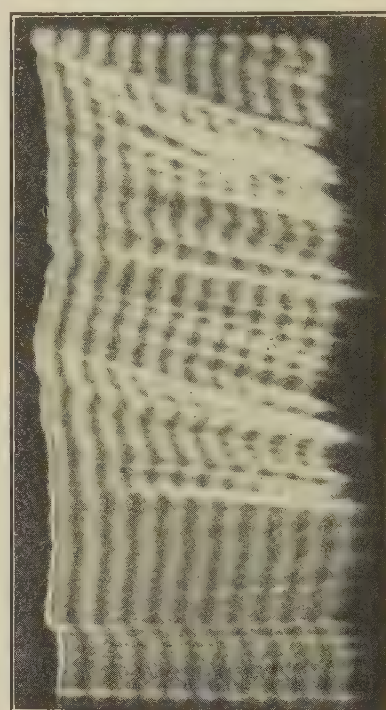


Fig. 6—Nine-Foot Vertical Flashover from Point to Floor

Moving-film photograph of flashover of 11 half cycles duration

perceptible at the positive half cycles on the moving films. But when the gap was next opened up to 22 ft., discharges appeared on every half cycle just before arc-over. On the films, the alternate half cycles of brush discharge were found to be strikingly similar, while the succeeding half cycles were different, indicating that the positive and negative discharges each had their own decided characteristics. As the point discharge first begins to appear on the moving film with the rising voltage, there can be seen on the negative half cycles either no visible signs of discharge or one heavy stalk or jab with a corona head at the end of it, indicating a small voltage drop along its path, so that the field terminates chiefly at its end, and produces a brush head effect there. As the voltage approaches arc-over, these intense white negative jabs increase in length and brilliancy and may occur more than once on an occasional half cycle. The positive discharges, however, seem to be more prolonged over their corresponding voltage crests, branching out continually and to greater lengths than the negative discharges, but with less luminous intensity

than the latter. They come in earlier, also, and consistently appear at each alternate half cycle. The fact that no long intense negative streamers appeared at the 10-ft. spacing, both electrodes insulated, apparently indicated that they required much higher voltage gradients.

In the work on space charge carried out at Stanford two years ago,[5] it was found that at the start of corona, the region between two conductors was built up to a slight negative potential above ground due to the corona rectification. The sign of the charge soon reversed with increase in voltage, and near the flashover voltage, the space had been charged to an appreciable positive potential above ground. Since it is at this point that the long intense streamers appear from the negative electrode, it would seem that they merely serve to dart out at intervals to drain different portions of the field of the heavy positive space charges there.

By means of a stroboscope, it was possible to check visually the electrode discharge figures obtained on the moving films.

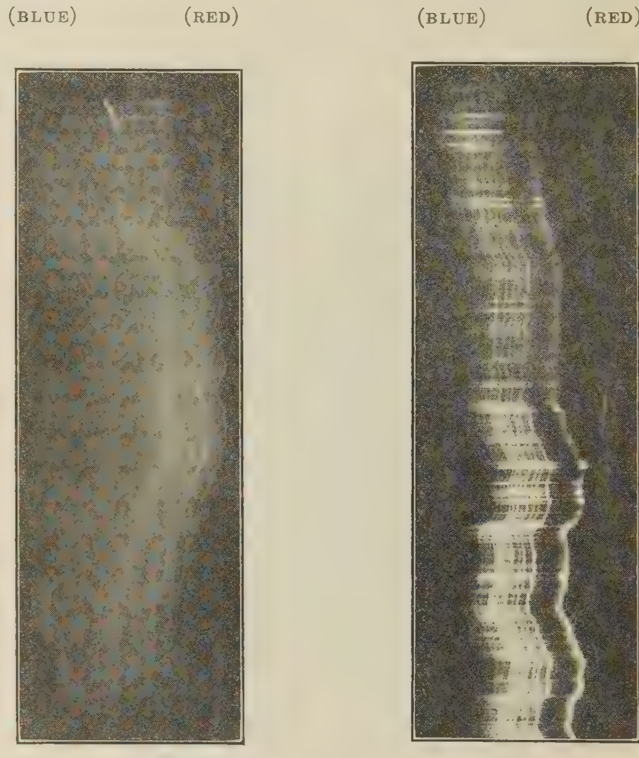
The physical appearances of the point brush discharges found above seem to display features which fit in rather well with the oscillographic records of corona current obtained. On these current waves, (one of which is shown in Fig. 3), the many needle jabs on each positive half cycle probably serve to supply the tree-like channels continually branching out when the electrode is positive. On the negative current crests, the smooth part of the wave is probably indicative of the current supply to the short negative glow, while the single sharp peak with it, (if it occurs) would be associated with the ordinary single heavy streamer that is seen on the negative half cycle on the moving film.

In photographs of laboratory flashovers of insulator strings, condenser-like discharges sometimes are visible along paths other than that over which the actual flashover finally develops. These are undoubtedly initial discharge breakdowns to ground at a time when the voltage are too low to provide sufficient energy ($1/2\ C\ E^2$) to render the path conducting enough for the arc to follow. Fig. 4 shows the oscillogram of a voltage wave several cycles before flashover of a 20-ft. point-gap, where a brief drop in voltage at one crest can be seen, which probably occurred simultaneously with some such temporary pre-flashover condenser discharge.

Spectrographic Analysis of Flashovers

Next, in an attempt to identify some of the factors contributing to its various conductivities spectrograms were taken of the different stages of a flashover. By arranging a shutter that would open for only the start of a flashover, it was possible to secure the spectrum of the initial intense discharge which was found to bridge the gap at the beginning of the first half cycle of arc-over on each of the moving film photographs, (Figs. 5 and 6). Fig. 7a shows one of the spectra, obtained in this manner, of a 10-ft. discharge from a point to a plane. This was identified as the spark spectrum of air and is practically identical with that of lightning, as can be seen from a comparison with a lightning spectrum as obtained by Fox,[6] which appears in Fig. 7b. In every laboratory flashover so analyzed the initial discharge was found to give the spark spectrum of air.

In these spectrograms of the initial spark it was noticed that arc lines of metal vapor appeared at the electrodes. In the discharge of Fig. 7a, where an aluminum electrode was used, typical aluminum arc lines are visible at the upper end. In order to ascertain how soon metal vapor appeared in a flashover, a moving



(a) (b)

Fig. 7—Comparison of Laboratory Sparkover and Lightning Spectra

(a) Spectrum of initial spark bridging 10-ft. point-to-plane gap, which started first half cycle of complete 60-cycle flashover

(b) Spectrum of lightning stroke. (Fox-Yerkes Observ.)

film spectrogram of about one inch of the discharge at the electrode point was obtained, making use of a slit. This was carried out for aluminum, copper, and iron electrodes. In every case the presence of metal vapor was detected in the initial spark discharge starting the first half-cycle of arc-over, the aluminum showing up most intensely. Since iron vaporizes at 2450 deg. cent., it would seem that temperatures sufficient for thermionic emission at the electrode are probably reached at the very first spark breakdown of the gap. Factors other than heat, however, may possible come in to facilitate vaporization during the first air spark, since the initial high-voltage gradient at the electrode may provide sufficient bombardment by positive ions, or

strong enough electromechanical forces, to remove metal particles from the electrodes which, in turn, would be vaporized. Nevertheless, it is interesting to find metal vapor present within the first one thousandth of a second of flashover.

It was not possible to secure a recognizable spectrum of the arc itself in the center of the gap after the first sparkover. In some short spectrographic exposures made of the 10-ft. flashovers, it was apparent from the metal arc lines visible that metal vapors extended out from the electrodes an appreciable distance within the first two cycles of flashover, at least 8 or 10 in. in the case of iron, and about 6 in. with aluminum.

The Probable History of a High-Voltage A-C. Flashover

Factors Involved. Undoubtedly ionization by collision, as originally suggested by Townsend and later amended by others,[7] plays an important role through out an entire high-voltage a-c. flashover. At the start, it is the essential factor in breaking down the air column between electrodes. Later, thermionic emission and metal vapors enter to enhance the conductivity of the channel, the former giving its pure electron supply from the electrodes, while the other provides a much more easily ionized medium for conduction.

Process of Breakdown. When the potential across a gap or over an insulator string becomes sufficiently great due either to the alternating voltage being increased or an impulse wave superimposed, two corona streamers from opposite electrodes will meet and bridge the gap. (No experimental evidence has yet served to explain the exact details of this contact.) The condenser capacity of the electrodes and its attached parts will then discharge across, giving an intense initial spark. If, due to a too low applied voltage, the stored electrostatic energy ($1/2\ C\ E^2$) is not great enough to provide a sufficiently heavy discharge for starting adequate thermionic emission or metallic vaporization at the electrodes, the gap breakdown will cease, and the voltage wave will return to normal, similarly to the one shown in Fig. 4. On the other hand, should the initial discharge be ample to create sufficient thermionic emission and metal vaporization at the electrodes, (and possibly a certain amount of sufficiently ionized and excited gaseous bodies in the gap), then the conductivity of the channel will be increased enough to allow the discharge to be maintained though the voltage wave continues to drop through the remainder of the half cycle, as seen in Fig. 1. On the next half cycle the discharge has to form again, but due to many of the particles in the gap being either already ionized or in an unstable state, it requires only a small voltage rise before the gap is again broken down, whereupon the voltage wave falls once more. As the arc-over current increases, which it surely must unless the effective applied voltage is dropped appreciably, less and less voltage is required to break down the gap each half cycle. Probably ionization by collision occurs at the beginning of every half cycle, although in a fully developed power arc, with copious thermionic emission and metal vaporization in existence, it would require but a small initial voltage for it to start the discharge each time. Thermal agitation and slight photoelectric effects probably enter to assist in the ionization process by "exciting" neutral bodies, but it is highly questionable whether they, in themselves, do any actual ionizing.

Acknowledgments

Doctor Ryan suggested this study of flashovers and has been a valuable source of assistance and guidance throughout the work. Professor J. S. Carroll took part in all of the tests and is largely responsible for many of the results obtained. Mr. Bradley Cozzens of the laboratory staff also assisted in much of the work.

Doctor L. B. Loeb, of the Physics Department of the University of California, very generously helped the author to secure the facts regarding electrical breakdowns as known to physicists, and continually pointed out the meaning of many of the laboratory results obtained.

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A HYDROGEN-COOLED GENERATOR

A brief note describing the operation of what is probably the first commercial electrical machine to be cooled with hydrogen instead of air, has been received from W. J. Foster, Chairman of the Committee on Electrical Machinery.

The New England Power Co. installed early this past summer an out-door, hydrogen filled, synchronous condenser made by the General Electric Co. The hydrogen is circulated by the fan action of the rotor through specially designed water coolers placed in the two ends of the machine. The water circulation is common with that provided for the transformers.

This synchronous condenser, rated 10,000 kv-a. at 13,800 volts when operated in air, has been carrying a load of 12,500 kv-a. at approximately 14,000 volts every day since June 26th when it was put on the line. The temperature of the stator windings, which is determined by embedded detectors in the armature slots installed in accordance with the Standards of the A. I. E. E., and recorded by a temperature recording instrument, has been quite uniformly 65 deg. cent. all summer.

The condenser is in the Pawtucket outdoor station with oil switches and transformers and is said to be fully as quiet and well-behaved as its neighbors. The quantity of hydrogen required to keep the purity up to that specified has averaged 7.5 cubic feet per day.

Abridgment of

Impulse Flashover of Insulators

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Associate, A. I. E. E. — Non-member

Synopsis.—For the most part, this paper is a discussion of the mechanism of insulator flashover. The breakdown of air between electrodes, with particular consideration of the effect of various factors upon the flashover characteristics of insulator strings equipped with arcing rings, is discussed. It is shown that critical dimensions and spacings of arcing rings exist for a given insulator string. If the arcing rings are designed to lie on the safe side of this critical point, cascading flashovers will not occur: if the arcing ring dimensions are below the critical values, cascading may or may not occur, depending upon the nature of the applied voltage wave. Data from tests, which determined the limiting physical dimensions of arcing rings will prevent cascading under all types of impressed voltages, are presented.

* * * * *

Introduction

COMMONLY, transient voltages on transmission lines are attributed to three sources—switching, induction from cloud fields, and direct lightning strokes. The most troublesome surges are of the last two classes.[1] These surge potentials often exceed the insulation value of the line, and a flashover follows. The surge flashover forms an ionized path which is highly conductive, and a short circuit on the energized transmission line results. The subsequent interruption may last for only a few seconds, but, if the power short-circuit current shatters an insulator, the line may be out of service for several hours, an occurrence which it is extremely desirable to avoid. Because the power current will naturally follow the path established by the surge, a thorough study of the nature of surge flashover is involved directly in the problem of preventing insulators shattering.

Wave Shapes and Specifications—Preliminary Tests

One of the first effects noticed was that the nature of the flashover of a string of insulators changed quite perceptibly with different types of applied voltage waves. When the active portion was at the crest of a wave, or even on the front of a slowly rising wave, the arc sometimes cleared all, or nearly all of, the insulators. But when breakdown occurred on the front of a steep wave, the arc formed between the metal parts of the insulators, cascading the string. Even with many forms of arcing rings and horns, cascading resulted when steep waves were applied. In designing arcing rings for an insulator string, the first consideration is to insure that all arcs will take place between the rings. At the same time, it is desirable to maintain or increase the flashover voltage of the string by improving the gradient along the string. However, the flashover voltage between rings under all conditions must be less than that of the string with improved gradient. From the above, obviously the most difficult condition to satisfy is the prevention of cascading with rapidly rising voltages; and this really includes all others.

We now can summarize the factors involved in a study of the surge flashover of insulators, as follows: the characteristics of the applied voltage; the breakdown of air at atmospheric pressure; the electrostatic field or voltage stress distribution, and hence, the nature of the electrodes.

Breakdown of Insulators

The flashover of a string of insulators is not so simple a process as the breakdown of air between electrodes.

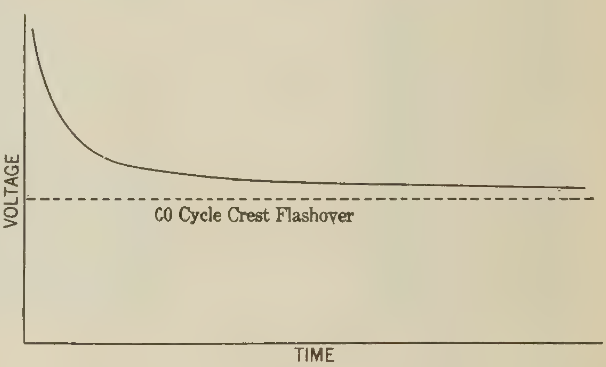

Fig. 3—Typical Breakdown Curve of an Air-Gap

A knowledge of the electrostatic field and of the stress distribution along the string is necessary. Calculations based upon the potential theory advanced by Ollendorf[4] have been made and checked in the laboratory. Ollendorf replaces the insulator string by two spheres of suitable diameter, one representing the line insulator and the other the ground insulator. He neglects the effect of the intermediate insulators upon the field by considering that their charges are bound. Thus, the effect of any charge is nearly neutralized by an equal and opposite charge displaced no more than the length of an insulator. Below breakdown values, voltage distribution curves calculated with these assumptions check closely with experimental curves. Fig. 4 shows the distribution on a plain string of seven suspension insulators raised to breakdown potential. Most of the

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1. For references see Bibliography.

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stress is across the two units adjacent to the line. The seventh or line unit is stressed well above its breakdown value. However, there is a current between the porcelain sections of the string tending to equalize the stresses across the units. This is a conduction current through the air, and the maximum possible current density without thermal ionization is low. Since time is required to transfer the charge, the average rate of voltage rise determines the equalization effect of this

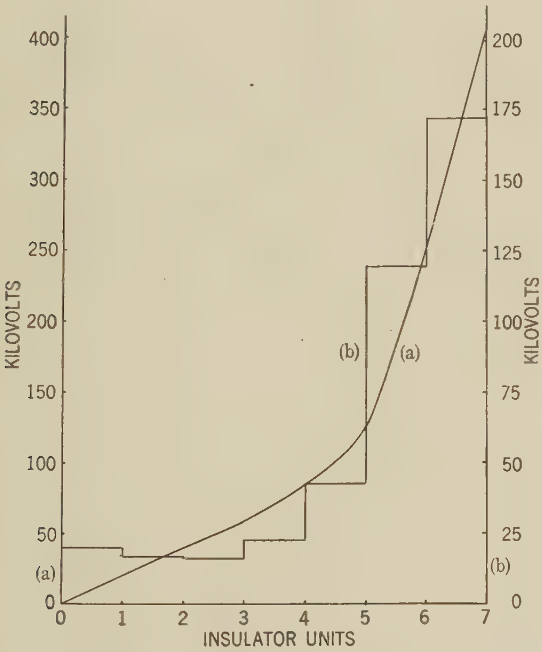

Fig. 4—Voltage Distribution (*a*) and Voltage per Unit (*b*) on a String of Seven Insulators

current. Therefore, with a rapidly applied voltage, one insulator will reach its breakdown value before the other units of the string. Streamers will start to form around this highly stressed unit. When it is shunted by streamers, its potential will be thrown across the remaining units, causing a new voltage distribution. The process continues at an increasing rate until the breakdown is completed. A time lag or breakdown curve similar to that of an air-gap exists for the flashover of an insulator string.

Arcing Rings

We may consider now a typical insulator string equipped with arcing rings. Data on a seven unit string equipped with 19-in. diameter rings of ¼-in. diameter material are available. The rings were located 3.8 in. from either end of the 39-in. string. Surges with a rate of rise greater than a certain critical value invariably cascaded the string. Surges with lower rates of rise struck between the rings. The comparative breakdown curves may be constructed as in Fig. 5. Since the rings have a lower 60-cycle breakdown value, the active portion of a given wave is reached at a lower voltage for the rings than for the insulators. The curves must cross at a point corresponding to the critical rate of rise. It will be noticed that for slowly rising waves, the active portion for the insulators may not be reached.

The following physical explanation may be made: For slow rates of voltage rise, the streamers forming from the rings span the entire gap before the active portion for the insulators has been reached; for moderate rates of voltage rise, the potential on the insulators reaches the active or streamer forming portion of the wave, but not until the ring streamers have almost completely spanned the gap; for rapidly rising voltages, the ring streamer development is sufficiently slow to permit the insulator potential to rise above breakdown value; hence, the insulator streamers develop into a cascading breakdown.

Laboratory experiments indicate that the streamers upon formation are fairly high in resistivity, and probably only a part of the charge is transferred to their tips. For this reason, the streamers of opposing electrodes will have less effect upon each other than might be expected. However, as the streamer progresses, the insulator-streamer component increases due to the relatively higher potential of the insulators at this point. This effect is increased further under steep surges by the unbalanced rise of potential on the insulators. A slight bending of the streamer toward the insulators produces an increase in the streamer insu-

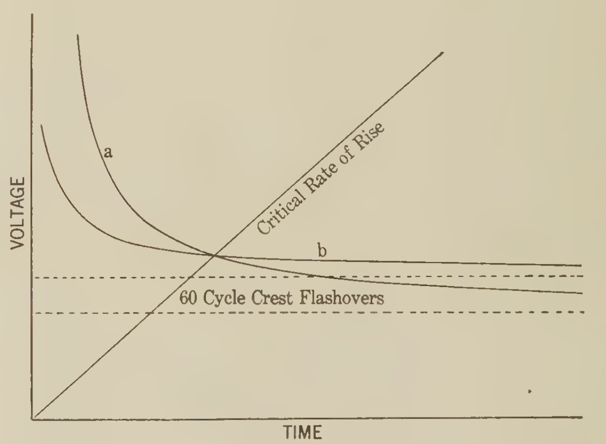

Fig. 5—Comparative Breakdown Curves for an Insulator String (*b*), and for an Air-Gap Between Arcing Rings (*a*)

lator component which forces the streamer to develop still further in toward the insulators. Thus, a slight bending or branching of the streamers in the early stages of flashover will result in a cascading, or partial cascading, flashover. This point is particularly important for long strings, such as 220-kv. transmission line insulation.

We may determine now the effect of various physical arrangements of the arcing rings upon their flashover characteristics. It is obvious that a homogeneous field between the rings is desired to speed up the streamer formation. The nearer the surface of the ring ap-

proaches that of a sphere, the more uniform the field will be. Therefore, the ring must be made of material of relatively large diameter. To prevent the streamers from being drawn into the string, a ring of comparatively large radius must be used. To aid in obtaining these results, the spacing or distance between the rings can be reduced, and this is usually necessary. However, due to the improvement in voltage distribution along the string resulting from the grading effect, a flashover voltage comparable to that of the plain string can be maintained. Obviously, the grading effect is lessened by an increase in ring radius, and the most desirable arrangement for a particular application will be a compromise.

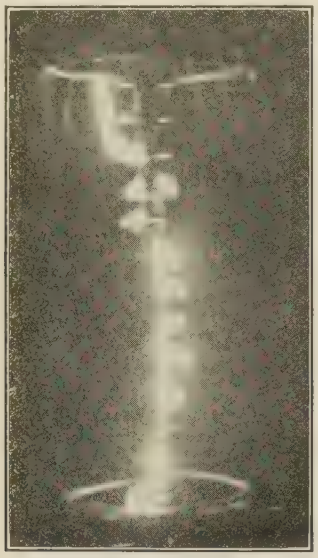

Fig. 10—Surge Flashover of an Insulator String with Improperly Applied Arcing Rings

Arcing Horns

The arcing horn has characteristics similar to the needle-gap. The stress distribution between opposing horns is very poor, since the section surrounding the horn tips has a relatively high gradient. Through a field of this nature, the streamers will develop slowly, and the potential across individual units will have time to build up and cause cascading. To overcome this sluggishness of operation, the distance between the tips must be reduced considerably. This adjustment is doubly effective; the point at which breakdown begins or streamers start to form is lowered, and the breakdown distance is reduced. Decreasing the spacing, however, has the serious disadvantage that the insulation of the line is lowered. When an arc exists, it must terminate at the horn tips, and is quite likely to be blown into the insulators.

The characteristics of the arcing ring are inherently much better. The stress distribution is uniform, permitting the streamers to grow rapidly. Consequently, spacings which do not lower the line insulation can be maintained. When an arc occurs between rings, it can travel around the rings. Hence, there is little chance of the arc being blown into the insulator string.

Tests

Test data on various arcing ring arrangements have been accumulated. Standard suspension insulator units 10 in. in diameter with 5⅝-in. spacing were used in the tests. Rings of ¼-in. diameter copper were first used to facilitate variation of the ring diameter and ring-to-ring spacing. The average rate of rise of the active portion of the generated wave was 7000 kv. per microsecond. This is somewhat steeper than lightning produces on transmission lines, as indicated by available data.[1] However, extensive measurements of voltage or wave form were not made.

At first, the rings were set at a definite spacing; that is, a definite percentage of the string length. Then the radius of the rings was increased until cascading ceased entirely with repeated voltage application. Thus, the minimum ring radius for a given spacing was obtained. Similarly, the maximum spacing for a given ring radius

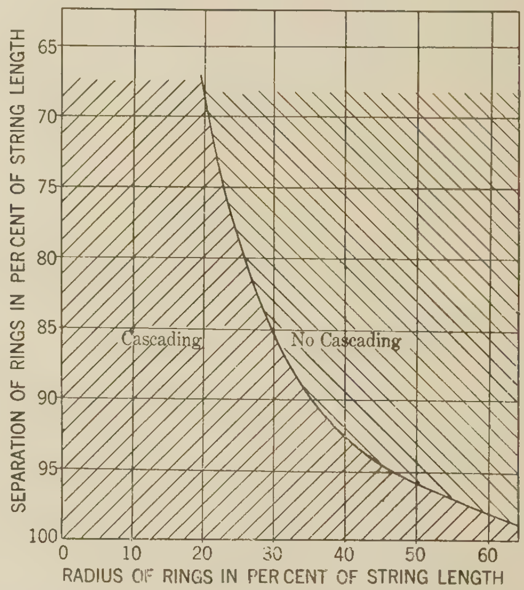

Fig. 11—Critical Arcing Ring Arrangements for Cascading and Non-Cascading Flashovers on a Seven Unit (39 in.) Insulator String

was determined. In Fig. 11, where critical ring spacings and ring radii are plotted in terms of the string length, is shown, graphically, the results of such a test for a seven-unit string. The curve divides the cascading and non-cascading regions. Thus, in order to keep the ring spacing or flashover distance above 90 per cent of the length of the plain string, for this particular case, the ring radius must be 40 per cent of the length of the string Where the ring radius is limited by tower clearances, the curve gives at once the maximum ring spacing. Similar tests were made with ring material of 1½-in. and 2-in. diameter. The results for the seven-unit string are shown in Fig. 12. For close spacing, the

larger diameter material is of no advantage. At greater separations, the larger diameter material permits the use of rings of smaller radius.

Conclusions

1. The breakdown of air is a progressive process requiring a finite period of time for the streamers developing from one or both electrodes to span the distance between electrodes. The time required is a function of the average gradient of the field.

2. The flashover of a string of insulators is a similar though more complicated process.

3. The nature of the flashover depends upon the rate of rise of the applied voltage. Cascading of the units of an insulator string is more likely to occur the faster the rate of voltage rise.

4. Cascading flashovers occur on the application of rapidly rising voltages because of the limited values of the leakage and conduction currents which tend to equalize the stress distribution of the units of the insulator string.

5. The path formed by the surge flashover furnishes a low resistance path for the power follow current.

6. Arcing rings will prevent cascading flashovers provided the time lag characteristic curve for breakdown between the rings is below the corresponding curve for flashover of the insulator string. This condition may be satisfied by conforming to definite physical relations between the ring-to-ring spacing, the radius of the rings, and the diameter of the ring material, as functions of the length of the insulator string to be protected. Furthermore, the radius of the arcing

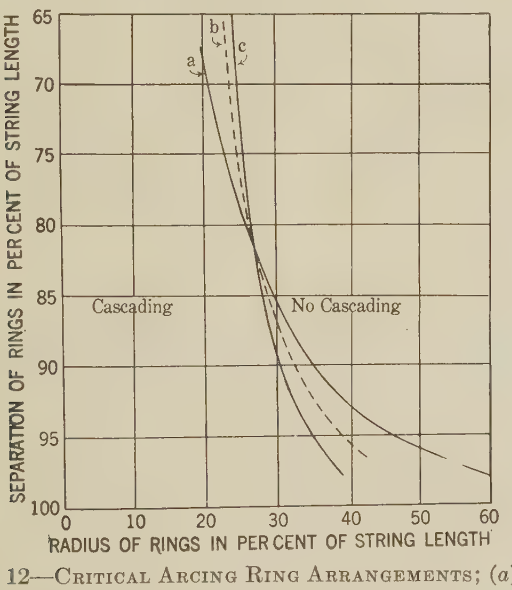

Fig. 12—Critical Arcing Ring Arrangements; (*a*) ¼-in. Diameter Material, (*b*) 1½-in. Diameter Material, (*c*) 2-in. Diameter Material; for Same String as Fig. 11

rings must be great enough to prevent the streamers from being drawn into the insulator string after they have started to form at the active sections of the arcing rings.

7. Arcing horns are unsuitable because of their high time lag characteristic, the decrease in flashover voltage necessary, and the likelihood of the arc being blown into the insulator string.

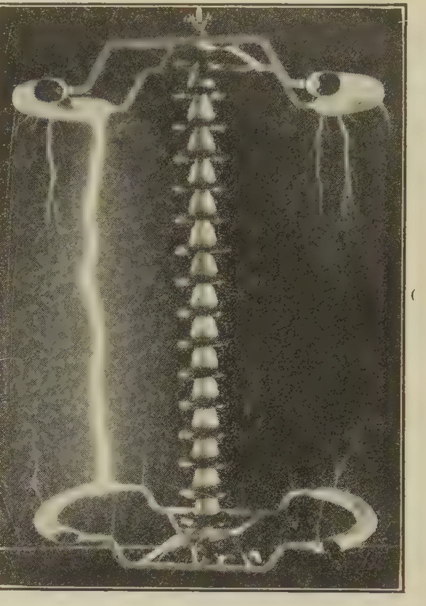

Fig. 13—Arcing Rings Designed for a 16-Unit Insulator String

The authors wish to express their appreciation of the assistance contributed by Messrs. J. Slepian, C. L. Fortescue, and P. H. McAuley.

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Good lighting, according to Clifford C. Paterson, president of the International Illumination Congress, is something akin to the perfect human character—"that which permeates all around it with charm and helpfulness, but effaces its own individuality." Mr. Paterson urges international accord and the comparison of experiences in lighting in order to make faster and more orderly progress.—*N. E. L. A. Bulletin.*

Abridgment of

Carrier Systems on Long Distance Telephone Lines

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Synopsis.—The authors describe recent activities of the Bell System in the development of long distance multiplex telephone systems using carrier current methods. A new, so-called type C system which supplants earlier types of equipment is described in detail, together with suitable repeaters and pilot channel apparatus for insuring the stability of operation: the line problems are considered and typical installations pictured. The growth of the application of carrier telephone systems and their increasingly important part in providing long distance telephone service on open-wire lines are shown.

Introduction

In an ordinary telephone circuit, the electrical equipment is not called upon to transmit frequencies above about 3000 cycles per second. By the use, however, of higher frequency currents, which serve a "carriers," several additional messages may be transmitted simultaneously on the same pair of wires. In these carrier current systems the voice-frequency currents of each message are caused to "modulate" a high-frequency current. The resultant modulated current contains a band of frequencies which is displaced from the original voice-frequency band by the amount of the carrier frequency. At the receiving terminal in a multi-channel system, the various incoming bands of high-frequency currents are separated by electrical filters. Then, by "demodulation," the original voice-frequency currents are reproduced and reach the proper listener.

At the Midwinter Convention of the Institute, 1921, Messrs. Colpitts and Blackwell presented a paper entitled *Carrier Current Telephony and Telegraphy.*[1] This paper included a brief historical summary—as well as a theoretical discussion, of the methods involved —and detailed descriptions of carrier-current apparatus which had at that time found employment in the telephone plant. The thermionic tube and the wave filter formed the basis of these pioneer commercial systems.

The Colpitts-Blackwell paper described two kinds of carrier telephone systems then in operation,—a four-channel "carrier suppressed" system, (type A) and a three-channel "carrier transmitted" system (type B). While these earlier systems were effective in bringing about economies by avoiding the stringing of additional wire on many pole lines, there remained many opportunities for improvement in performance and simplification of equipment. The result has been the development of a new (type C) system, which is technically a material improvement over its predecessors and which is also less expensive.

The Type C System

The new system is essentially a long haul multichannel system. It adds three high-grade telephone circuits to the facilities normally afforded by a single pair of wires and can be used over the longest circuits likely to be encountered in the Bell System. For the longer distances, repeaters are required spaced at intervals of from 150 to 300 mi. An important feature of the longer installations is the so-called pilot channel by which stability of transmission over the three carrier channels is assured despite relatively large variations in high-frequency line transmission due to weather changes.

The type C system is a "carrier suppressed" single sideband system. In this respect, it is similar to the older type A system. In the matter of the frequency allocation of the channel bands, the type C system possesses one of the features of the older type B system, the use of different carrier frequencies for transmission in opposite directions. Experience with the older systems has led to the conclusion that this two-frequency method of operation is to be preferred in the telephone plant.

A Complete System

The simplified layout of a complete system is shown on Fig. 1 (Fig. 2 of the complete paper). It will be noted that it includes apparatus at a terminal, a line circuit, a repeater station, a second line circuit and apparatus at a second terminal. Obviously, the number of line sections may be extended by the use of a greater number of repeaters.

At each end there are the terminations of the three carrier channels, 1, 2, and 3 and the regular voice circuit, 4. These terminations ordinarily appear at the long distance switchboard. When a subscriber is connected to one of the terminations,—for example No. 1,—speech currents pass through the three-winding "hybrid" coil, thence into the modulator circuit, where they are

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1. A. I. E. E. Trans. 1921, Vol. XI, p. 205.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928. Complete copies upon request.

caused to modulate a high-frequency carrier current. The resultant modulated bands[2] of frequencies pass through a filter allowing only the desired band of frequencies to pass to the transmitting amplifier. Thence, this band passes through a so-called directional set, whereby the regular voice range currents are separated from the higher frequency carrier current at both terminal and repeater offices.

The other two carrier channels function similarly, and the several modulation bands of carrier frequencies

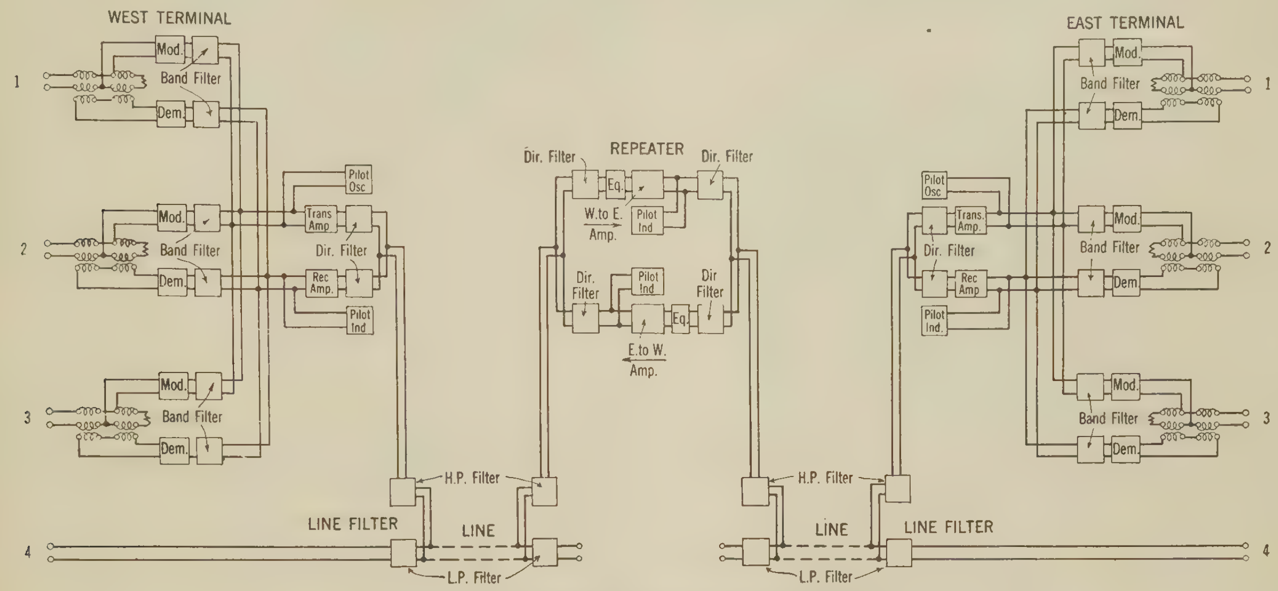

Fig. 1—A Complete Carrier System Schematic

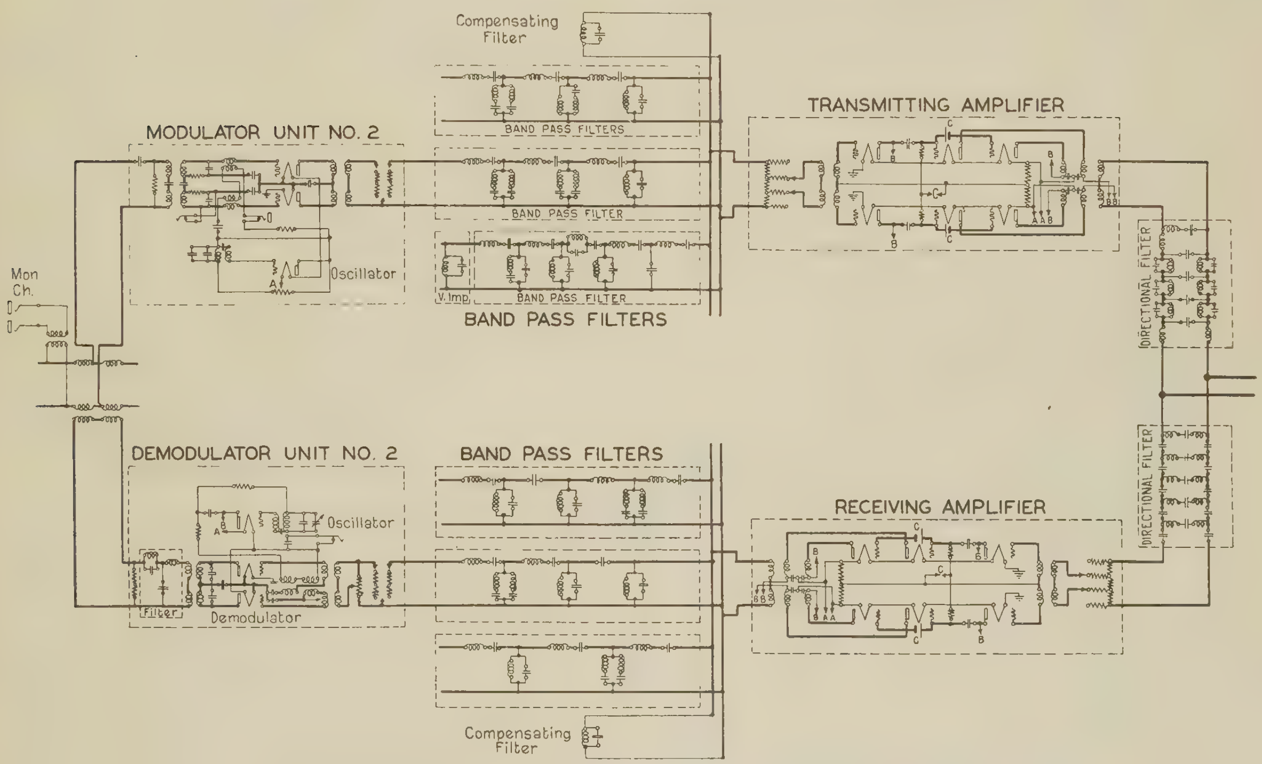

Fig. 2—Schematic Diagram of Type *C* Terminal Circuit

filter and a high-pass filter to the line circuit. The high-pass filter last referred to, in association with its complimentary low-pass filter, forms a so-called "line filter" join the first channel in passing through the common amplifier and directional filter circuit to the line. At a repeater point, the group of bands comprising the three channels in a given direction passes through the high-pass line filter circuit; thence through a directional filter and amplifier circuit and outward through a

2. Loc. cit. or R. V. L. Hartley. "Relation of Carrier and Side Bands in Radio Transmission," Bell System *Tech. Jl.*, Vol. 2, April 1923, p. 90-112.

similar directional and line filter circuit to the next line section. At the farther terminal, the several carrier currents pass through the directional filter and are again amplified in the receiving amplifier. At the output of the amplifier the different carrier channel bands of frequencies are selected, one from another by the band filters, thence they pass to their respective demodulator circuits, are demodulated to their original form and finally pass from the output connection of the hybrid coil to their terminations.

Fig. 2 (Fig. 3 of the complete paper) shows diagrammatically in somewhat greater detail the terminal circuits of the type C system. The modulator circuit consists of a two-tube push-pull grid-bias circuit in which the carrier frequency is balanced out. A separate oscillating tube circuit of exceptional frequency stability supplies the carrier current. The frequency allocation requires the transmission of the upper or lower sideband frequencies only and at the output the band filter selects the desired band, rejecting the other products of modulation. The common amplifier is a two-stage vacuum tube unit having four tubes in the output circuit arranged in parallel push-pull connection to insure the required load carrying capacity. The demodulator circuit is also a push-pull grid-bias vacuum tube circuit in which the voice-frequencies are derived by the modulation of the sideband currents with a carrier frequency supplied by the local oscillator, adjusted accurately to synchronize with the frequency of the corresponding transmitting modulator at the farther terminal. It is obvious, of course, that if the carrier frequencies of the modulator and the corresponding demodulator of the same channel are not in sufficiently close agreement, there will be a serious distortion of the speech currents received over the channel. No difficulty is experienced in keeping these two oscillators within a frequency difference of from 10 to 20 cycles. This has been found quite adequate.

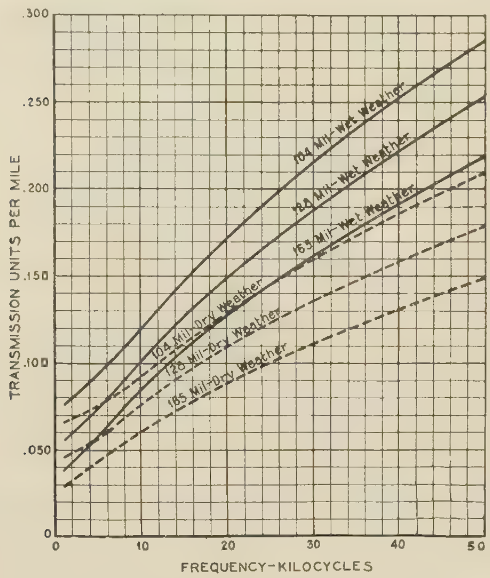

Fig. 3—Attenuation Curves for Open-Wire Lines of Different Gages at High Frequencies

Line Considerations

Because of skin effect in the wires and rising losses in the insulators, the attenuation of the open-wire circuits on which carrier systems are applied increases steadily with frequency. Unfortunately, the losses of the insulators are not constant and they increase greatly with the presence of moisture. This brings about an increase in attenuation in rainy weather and requires the use of pilot channel apparatus in order

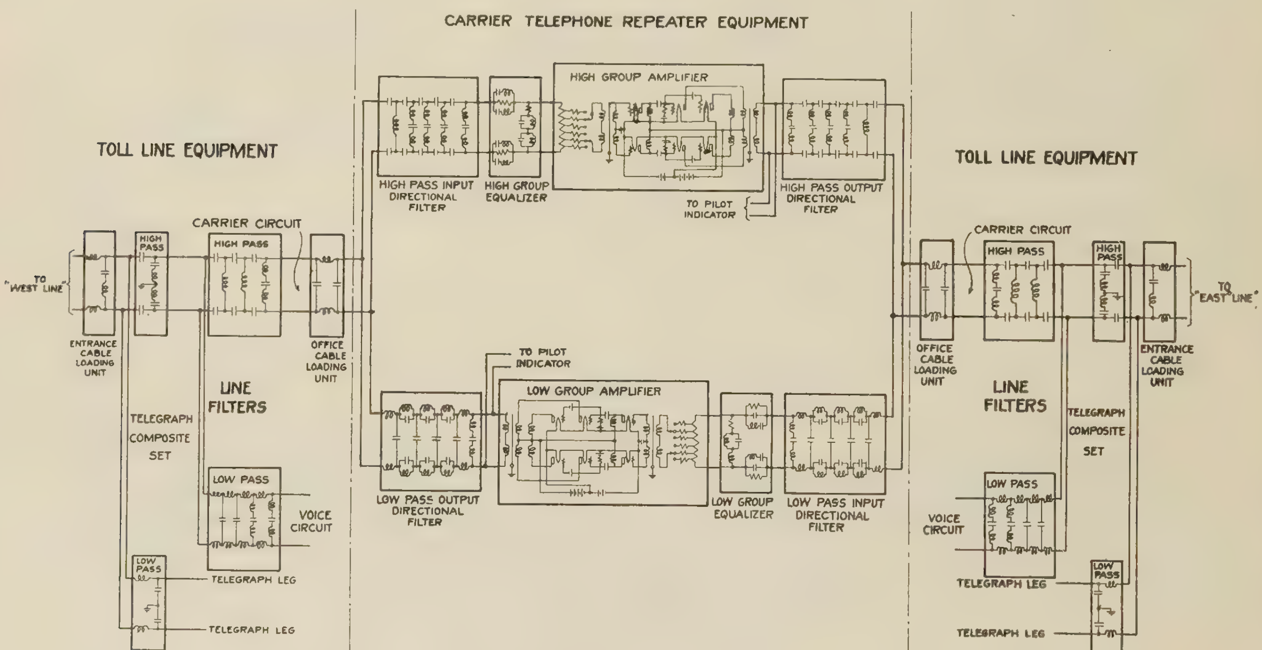

Fig. 5—General Schematic of Carrier Repeater Circuit with Associated Line Equipment

to insure the necessary stability of transmission, as later described. Fig. 3 (Fig. 10 of complete paper) gives representative attenuation frequency curves for the more commonly employed gages of wire.

If care is not observed the carrier currents on the line may be interfered with by cross-talk from other carrier systems or by miscellaneous currents which enter the circuit by induction from the outside. The latter may manifest themselves as noise at the carrier terminals. By the exclusive use of a metallic circuit, adequate design of apparatus and care in the layout of

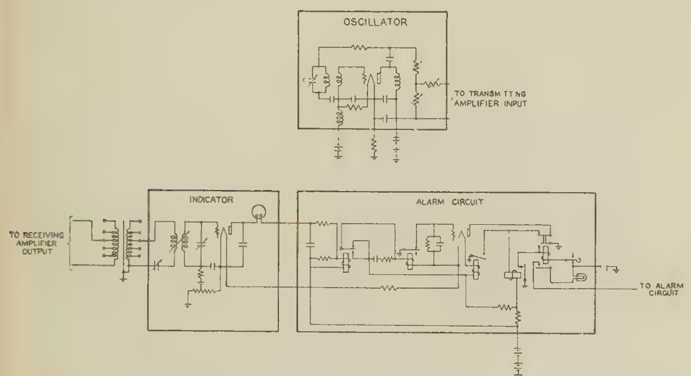

Fig. 6—Schematic of Pilot Channel Circuits. (The Alarm Circuit is used with Terminals Only)

the systems, it is possible to insure that the carrier currents have the required margin over the noise currents.

In the matter of cross-talk between systems closely adjacent on the same line, the situation is alleviated by providing two frequency allocations, (see Fig. 5 of the complete paper). These are "staggered" with respect to one another, so that a system installed on one pair using so-called *N* frequency allocation has less cross-talk to and from a system installed and operating on an adjacent pair and using the so-called *S* frequency allocation than would be the case if both systems employed the same allocation.

Repeaters

Repeaters must be employed when the distance exceeds that for which the terminal transmitting apparatus is effective in maintaining the transmission level well above the line noise. Repeater station spacings vary from 150 to 300 mi. depending on circumstances. A schematic diagram of a repeater station is shown on Fig. 5 (Fig. 6 of the complete paper). An amplifier similar to that employed at the terminals amplifies the several channel currents simultaneously. The use of directional filters whereby the channel frequency bands of the opposite directions are kept apart in their respective amplifier circuits makes possible the use of the substantial amplification or "gain" needed to offset the relatively high line attenuation. Equalizers as shown provide the non-uniform frequency-amplification characteristic required to offset the rising frequency-loss characteristic of the line circuits.

Pilot Channel

As previously noted, the attenuation of open-wire line circuits of substantial length is markedly affected by weather conditions. Thus it becomes necessary to make occasional gain adjustments throughout the system. The extent of these adjustments is determined by means of the pilot channel which provides a visual indication of the transmission levels at repeater points and terminals without interfering with the speech currents over the channels themselves. It is in effect a separate constant-frequency carrier channel allocated between certain speech channels in each transmission group.

The operation of the pilot channel is relatively simple. At each repeater point and receiving terminal there appears a meter for registering the level of the pilot current at the output of the amplifier. The pointer of the meter is expected, normally, to rest at a point which represents the normal level layout of the system. If a change in the attenuation of the line circuit causes a departure in the transmission level, the meter reading shows a corresponding up or down indication, and by adjustments of the repeater or terminal amplifier potentiometers, the level may be returned to normal.

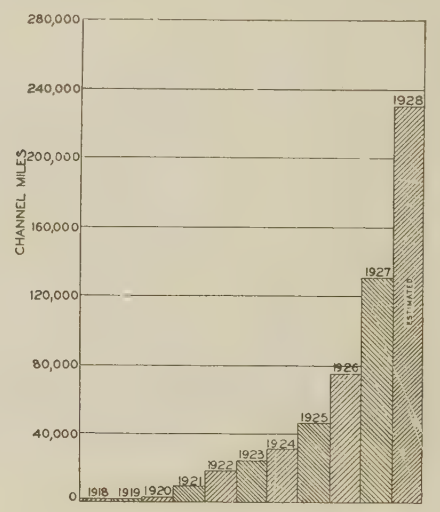

Fig. 10—Growth of Carrier Telephony in Bell System

An alarm circuit also is provided at the receiving terminal, so that when the level has departed by more than a predetermined amount from the desired normal, the operating attendant is called in to make an adjustment.

Fig. 6 (Fig. 8 of the complete paper) shows schematically the principal features of the pilot channel terminal circuit as a whole. An oscillator at each transmitting terminal providing the pilot current is connected to the carrier circuit at the input to the transmitting amplifier (see Fig. 1). The pilot channel indicator circuits are bridged across the outputs of the amplifiers at receiving terminals and repeater points. The circuit is tuned to discriminate very sharply against

all but the pilot current frequency. The alarm circuit includes a delay circuit which protects against possible slight transient interference into the pilot channel from currents in the other channels of the system and thereby insures that the alarm indicates only a definite level change.

EQUIPMENT PROBLEMS AND TYPICAL INSTALLATIONS

Like the development of toll cables, the increasing use of carrier telephony as a substitute for line construction in providing toll facilities on long circuits has resulted in further increasing the proportion of the plant investment represented by the equipment within the offices. The type C equipment is mounted on panels employing a uniform dimensional system in a manner similar to the other recent telephone developments. This has had advantages not only in giving the desired uniformity in design but in permitting grouping arrangements which have aided in effecting adequate electrical separation between apparatus units as well as between the wiring.

CONCLUSION

The carrier systems are meeting successfully and economically the requirements of long distance telephone service. From what has been written, however, it is evident that the apparatus is by its nature complex and to a fair degree expensive so that for relatively short distances it is cheaper to string wire. Systems are operating for distances of 150 mi. and upwards. The availability of the improved type C system within the last few years has greatly stimulated the application of carrier telephony in the Bell System. Fig. 10 (Fig. 1 of the complete paper) shows the growth of the systems since their first commercial application in 1918. How these systems are distributed over the lines of the Bell System is shown on Fig. 44 of the complete paper. The heavier density of use occurs in the middle and western sections of the country and in general where the circuit demand and growth have not yet reached the large figures required to justify the installation of toll cables.

While considerable progress has been made in the development and application of these carrier systems since the beginning of their use about 10 years ago, there is obviously still much to be done in the matter of simplification and further use of the high-frequency spectrum. While the systems now in use in the field employ frequencies no higher than approximately 30,000 cycles, frequencies considerably higher than this can undoubtedly be economically employed.

Abridgment of

Application of Wound Type Current Transformers Installed in High-Voltage Oil Circuit Breaker Tanks

BY J. C. REA[1]

Associate, A. I. E. E.

Synopsis.—Wound type current transformers installed in the tanks of high-voltage oil circuit breakers have been in operation for many years. The experience gained during this period has resulted in fairly clear definitions as to the types of installations to which they are best suited, and to designs of transformers which are highly reliable. The purpose of this paper is to present a brief history of some of the developments leading up to the present application of wound type current transformers in circuit breakers and to indicate some of the conditions under which they offer special advantages.

* * * * *

IN the early stages of the electric power industry the oil circuit breaker made its appearance as a solution of the problem of interrupting circuits under load and it was not surprising that efforts were soon made to develop automatic mechanisms which would cause the circuit breaker to open itself on over-current. Some of the earliest forms of devices for performing this duty took the form of solenoid coils connected in series with the circuit controlled by the circuit breaker.

Devices of this nature all had the serious defect of requiring very delicate adjustments because the amount of energy available was very small. They also lacked a satisfactory means for varying the time delay.

These defects were readily overcome by the use of current transformers connected to suitable relays. The desired time delay characteristics were obtainable with this combination and additional features such as differential protection, reverse power control, etc., could also be obtained. In many cases, however, the current transformers added a very considerable item of expense to the installation, particularly in the higher voltages.

The use of the entrance bushing on the oil circuit

1. Chief Engineer, Pacific Electric Mfg. Co., San Francisco, Calif.

Presented at the Northeastern District No. 1 Meeting of the A. I. E. E., New Haven, Conn., May 9-12, 1928. Complete copies upon request.

breaker offered a means to provide insulation for the primary circuit of the current transformer, eliminating one of the heaviest items of expense in connection with its use. These means were used either by applying a bushing type transformer in which the primary winding was formed by the conductor passing through the bushing, or a transformer with a primary coil wound on the core and mounted in the oil circuit breaker tank.

Early Forms of Transformers

An early form of transformer of this type was designed for use with circuit breakers having dimensions already established. It was necessary to make the primary coil as small as possible and to aid in obtaining this result, the secondary coil was placed on the leg of the core opposite to that on which the primary coil was located. The core was given an equal amount of insulation, both from the primary and the grounded secondary coil, so that the dielectric stress on the insulation at the primary coil was considerably reduced from that which would have existed if all of the insulation has been applied at one point. Transformers of this type were applied to oil circuit breakers ranging from 22,000 to 110,000 volts.

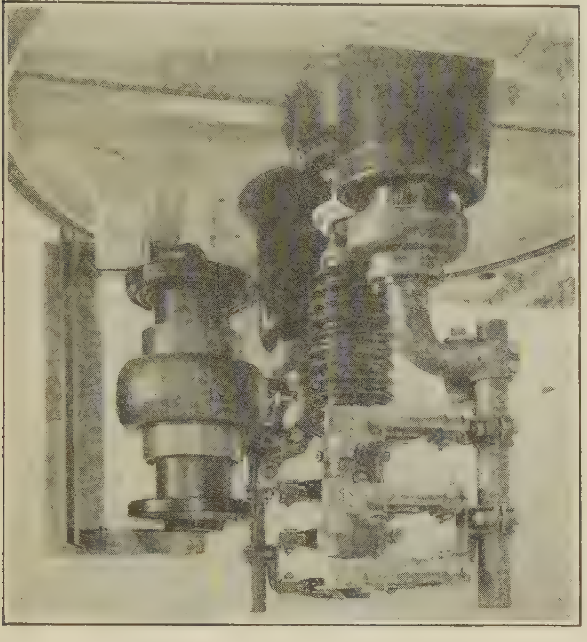

Fig. 1—73-Kv. Oil Circuit Breakers With Modern Wound Transformer

The accuracy of ratio and phase angle of these transformers with wound primary coils was not sufficient to permit their application to metering.

Further development was made possible by increasing the space available inside of the tanks, permitting the physical dimensions of the transformer to be increased. Improved electrical characteristics were obtained by mounting the primary and secondary coils concentrically upon one leg of the core and increasing the number of ampere-turns and cross-section of core. The characteristics thus obtained made the transformer suitable for metering. The mechanical strength of the transformer as a unit, and also of its mounting in the oil circuit breaker, were also greatly improved by this construction.

The insulation between the primary and secondary coils presents a rather unusual problem because of the possibility of the transformer being operated, at times, in oil of reduced dielectric strength. It is also necessary to provide for a possible accumulation of carbon and other deposits which may adhere to the surface of the insulation.

A type of construction for the major insulation which has proved highly satisfactory consists of concentric tubes of laminated phenol compound supported on rings of the same material. Shoulders are turned on the tubes and the supporting rings are pressed against them so that the tubes cannot slip along their axis. The free circulation of the oil between the tubes is insured by perforating the supporting rings. This construction provides for a very long leakage path between the primary coil and ground.

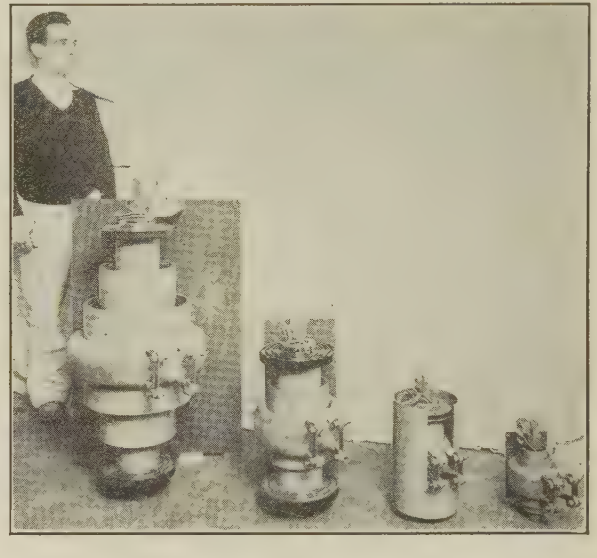

Fig. 2—Comparison of 132-Kv., 73-Kv., 37-Kv., and 25-Kv. Transformers

Additional leakage surface is obtained by applying a porcelain tube with a corrugated flange at each end of the Bakelite insulating tube.

Modern Designs of Transformers

Figs. 1 and 2 show typical transformers of this construction. The outer coil is the primary which in the transformer illustrated is wound in two sections. Links are provided to permit the sections to be connected, either in series or parallel to obtain two different ratios. The secondary coil is wound on a tube which fits against the core, directly under, and concentric with the

primary coil. The secondary leads can be seen, running out to the secondary terminal block at the top of the transformer. The symmetrical arrangement of the coils limits the mechanical forces due to heavy primary currents to a minimum.

The mounting of a current transformer in an oil circuit breaker tank calls for particular care because of the mechanical shocks to which the transformer is subjected during the interruption of the circuit by the oil circuit breaker. It has been found that if very substantial support is given to the core of the transformer, it will withstand these shocks without sustaining injury.

Fig. 1 shows a typical mounting of one of these transformers in a multiple break oil circuit breaker of the rotary type. The core is held rigid by a bracket which is secured to the cover of the oil circuit breaker. The primary coil is in turn fastened to the lower end of the entrance bushing by means of heavy copper links. The location of the transformer relative to the contacts of the breaker is such that it is at no time endangered by proximity to the arcs, which are drawn upon opening the breaker. In extreme cases where the number of instruments to be operated exceeds the capacity of one transformer, two of these transformers can be mounted in each phase of the oil circuit breaker. In this case, one transformer is applied to each of the entrance bushings.

In some of the earlier transformers of this type trouble was experienced due to surges causing a failure of the insulation between turns in the primary coil. Various protective devices were tried. It was found that by applying very generous insulation between turns on the primary, all trouble from this source was eliminated and that protective devices to shunt the surges across the primary coil were unnecessary.

Applications

The application of wound type current transformers in the tanks of oil circuit breakers is particularly advantageous in meeting two distinctly different requirements. One of these cases is where it is necessary to operate watt-hour meters for measuring small amounts of power, where the required accuracy cannot be obtained from bushing type transformers. The second use to which these transformers can be very advantageously applied is to operate tripping relays where the primary current is low and the secondary burden on the transformer is high.

For the first case, Fig. 3 shows the ratio and phase-angle curves obtained with this type of wound transformers when operating with burdens of 0.1 ohm resistance 0.13 μh. or approximately 2½ volt-amperes, 90 per cent power factor, and of 0.6 ohms resistance 0.7 μh. or approximately 15 volt-amperes, 90 per cent power factor. These curves are characteristic of the type of transformers herein illustrated, over their total range of 5/5 ratio to the upper limit of 400/5 ratio.

Where extreme accuracy is needed, the ratios can be adjusted by turn compensation to get zero error at any per cent of primary load desired. This is accomplished by the use of two parallel secondary windings having an unequal number of turns. By choosing a suitable combination of turns for these secondary coils, the ratio for a given primary current and burden can be adjusted to any desired value.[2]

For the second case, Fig. 4 shows the relation between primary and secondary amperes of a conventional 50,5 ratio (10 secondary turns) bushing type transformer and of a wound type transformer of the same ratio. A rating somewhat below that generally considered the minimum for bushing type transformers was chosen so as to magnify the differences between the two types of transformers.

A point that is occasionally overlooked in the application of induction type over-current relays to current transformers is the excessively high burden which they impose on the transformer when they are connected on the low-current taps. A type of relay frequently used with bushing type current transformers has a nominal rating of two volt-amperes at the tap current. If such a relay is connected to the transformer and operated on the two ampere tap the impedance of the relay alone is approximately equivalent to a burden of 12.5-volt amperes at five amperes secondary current of the transformer.

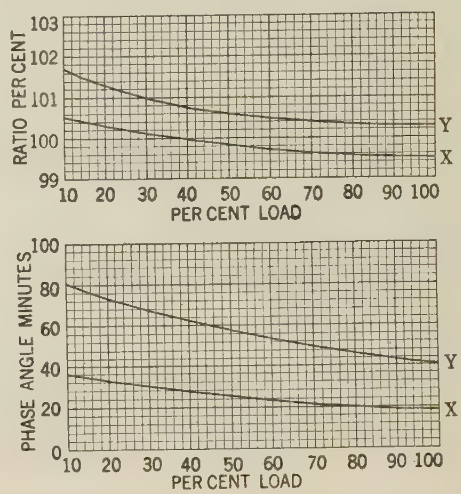

Fig. 3—Characteristics of Wound Transformer

X 2.5 Volt-amperes, 90 per cent power-factor burden
Y 15 Volt-amperes, 90 per cent power-factor burden

The usual installation of high-voltage oil circuit breakers, requires a considerable length of wire to be run between the current transformers and the relays. Using No. 10 copper wire for the secondary leads, the volt-ampere burden added by the wire is approximately five volt-amperes for each 100 ft. of distance between the transformer and relay. The curves marked W Y and

2. Patent No. 1,550,906.

R Y in Fig. 4 would be those resulting from the use of a two volt-ampere induction type relay connected on the two-ampere tap and mounted 50 ft. from the oil circuit breaker. Using a 50/5 ratio transformer it would be expected that the relay would trip the breaker at a minimum of 20 amperes, primary current. The chart shows, however, that while this would be true with the wound type transformer it would require a minimum of 30 amperes primary current to operate the relay from the bushing type current transformer. Approximately the same burden would be obtained with a 12-volt-ampere relay connected on the five-ampere tap, or a 17-volt-ampere relay connected on the six-ampere tap, when either relay is located 50 ft. from the current transformer.

The curves marked *W Z* and *R Z* are those obtained with a secondary burden of 50 volt-amperes, 50 per cent power factor. Approximately this amount of burden would be imposed by a two-volt-ampere relay connected on the one-ampere tap or a 17-volt-ampere relay connected on the three-ampere tap, either of these being located 50 ft. away from the circuit breaker. In this case, the bushing type transformer would require more than twice the primary current to operate the relay than that required by the wound type current transformer.

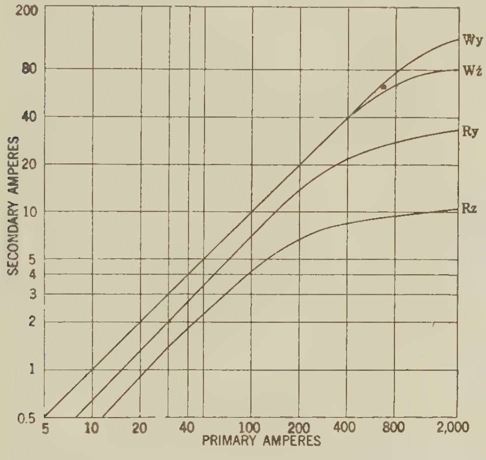

FIG. 4—COMPARISON OF 50.5 RATIO, BUSHING, AND WOUND TYPE TRANSFORMERS

W Y Wound transformer 15 volt-amperes burden
W Z Wound transformer 50 volt-amperes burden
R Y Bushing transformer 15 volt-amperes burden
R Z Bushing transformer 50 volt-amperes burden

It will also be seen that the ratio of the bushing type transformer varies considerably throughout the range of primary currents and that it becomes very bad at from five to eight times normal current, whereas the wound type transformer has a very small error until the primary current rises to around 20 times normal. This characteristic of the wound type transformer makes it particularly suitable for use on differential protection of transformer banks where the characteristics of the current transformers on both sides of the bank must be carefully matched in order to prevent the operation of the relays on heavy through short circuits.

The upper limit of ratios at which it is desirable to apply the wound type current transformer in circuit breaker tanks is fixed by two considerations. The one is a mechanical, and the other an electrical limitation. The duty required of the circuit breaker for rupturing heavy currents usually varies somewhat in proportion to the current which will normally be carried by the breaker. The mechanical strains placed on the transformer are greatly increased where the circuit breaker is used to interrupt very heavy currents. This means that even though transformers might be built for heavier primary currents than 400 amperes, their installation in circuit breakers, which are required to carry larger amounts of current, would in many cases be hazardous, because of the severe shocks to which they would be subjected under short circuits and the heavy mechanical forces which would be imposed on them by the explosion when the breaker interrupts the circuit. A second limitation places the 400/5 ratio as a reasonable upper limit for these transformers, because the accuracy of a bushing type transformer of this ratio is approximately as good as that of the wound type transformer.

Figs. 5, 6 and 7 show the comparison between ratio and phase-angle curves of a conventional 400/5 ratio bushing transformer and of the wound type transformer of the same ratio. The curves have been plotted on semi-logarithmic scale so as to condense the portion of the chart beyond full-load primary current. The curves in each case were taken without compensating the transformers for the particular burden. This permits direct comparison to be made from one chart to the other to observe the effect of changing the secondary burden on either transformer. These curves show that for a very low burden, the bushing type transformer has a better ratio but poorer phase angle than the wound transformer; and that if the burden is increased, the wound type transformer has much better characteristics than the bushing type.

CONCLUSIONS

1. Experience has shown that wound type transformers can be safely installed in the tanks of high-voltage circuit breakers, in many cases, at a very substantial saving of cost over externally mounted transformers.

2. For heavy secondary burdens these transformers can be built to give characteristics that are much better than those of bushing type transformers where the ratios are less than 400/5.

3. For light burdens the wound type transformers offer means of obtaining characteristics which are suitable for metering at low ratios where bushing type transformers would be entirely unsatisfactory.

Abridgment of

Surge Voltage Investigation on the 132-kv. Transmission Lines of the American Gas and Electric Company

BY PHILIP SPORN[1]

Member, A. I. E. E.

Synopsis.—Data on the surge voltage investigation, carried out under the auspices of the Subcommittee on Lightning, on one of the 132-kv. lines of the American Gas and Electric Company during 1928, are presented. Most of the surges have been segregated as to cause, and plotted in summary form for more convenient use. The magnitude and character of recorded surges are discussed, and the conclusions drawn from data presented.

Information on voltage surges due to lightning, switching, trip-outs, and unknown causes, are presented, as well as records of lightning arrester discharge currents, voltages across choke coils, and on the ground wire.

This paper is presented to make available to the engineering profession at this time some of the information already obtained, pending the complete report of the Subcommittee on Lightning. As experimental work is still being done in the field during 1928, anything approaching a complete report cannot be made until next year.

* * * * *

I. Introduction

In carrying out the work of the Subcommittee on Lightning of the A. I. E. E. Committee Transmission and Distribution, with the author as secretary, an extensive klydonograph layout was planned and placed in operation during the lightning season of 1927, on the 132-kv. system of the American Gas and Electric Company. This work, started under the sponsorship of the Subcommittee on Lightning, was made possible by the cooperation of the General Electric Company, the Westinghouse Electric and Manufacturing Company, and the American Gas and Electric Company, and it's subsidiaries; namely, the Ohio Power Company and the Appalachian Electric Power Company.

This paper presents some of the first data obtained from investigation on one part of the system. It is planned to combine with all the 1927 work data from other parts of the system where investigation was made together with results secured from the continuation of tests during 1928, and present it later as a complete report by the Lightning Subcommittee.

II. System Investigated

In selecting a system on which to carry out this work during 1927 the Lightning Committee decided that the 132-kv. Philo-Canton line of the American Gas and Electric Company was particularly well suited, as a great deal of lightning trouble had been experienced when this line was first placed in service.[2] After careful study, it had been supplied with protective equipment designed to minimize lightning troubles; and it was situated in a section of the country where lightning storms were known to be unusually severe.

The Philo-Canton line is a 73-mi. double-circuit A. C. S. R. conductor line, with wires in vertical configuration, one circuit on each side of the tower. The line is equipped with ring and horn protection on all insulator strings, and with one ground wire at the peak of the tower. This line is in Ohio, parallel to, and about 50 mi. west of the Ohio River. The 132-kv. system is operated with solidly grounded neutral, the only ground on the Philo-Canton line being at the Philo end.

In carrying out the program, tests were made also on a 132-kv. lightning arrester at the Turner substation located in Charleston, West Virginia.

This paper covers only results obtained on the Philo-Canton line and on the lightning arrester at Turner Substation.

III. Scope of Investigation

In planning the installation of instruments, locations were so chosen that it was expected valuable information would be obtained on the following:

1. Choke coil effectiveness
2. Ground wire protection
3. Polarity of lightning
4. Transient voltages on the ground wire
5. Functioning of lightning arresters
6. Attenuation of voltage surges
7. Voltage change at termination of ground wire
8. Switching surges
9. Action of tower ground resistance during insulator flashover
10. Relative surge voltages on symmetrically placed parallel conductor

The first instruments were placed in service May 10, 1927, and the major part of the installation completed about June 15. The investigation as a whole was concluded October 16, 1927, although some of the instruments at the stations, where they were accessible, were continued in operation throughout the winter of 1927-1928.

1. American Gas and Electric Company, New York, N. Y.

2. *Lightning and Other Experience with 132-Kv. Steel Tower Transmission Lines*, Sindeband and Sporn, A. I. E. E. Trans., Vol. 45, 1926, p. 770.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928. Complete copies upon request.

VII. Data Obtained and Analysis

During the period of instrument operation, up to October 16, 1927 approximately 3600 Lichtenberg figures, resulting from 550 surges, were obtained on the Philo-Canton section of the system. These surges were classified and regrouped so that a detailed study might be made of any particular type of surge. On the Philo-Canton line, these surges have been classified according to cause, as follows:

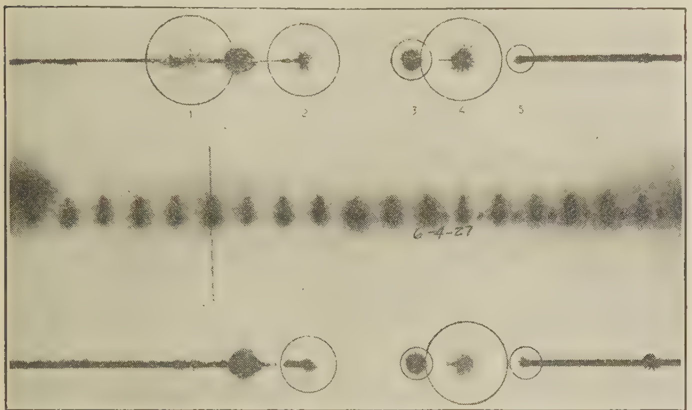

Fig. 4—Surge Voltage Recorder Field Record—Ohio Power Co.

1 typical lightning (HD) figure
2 & 4 (HD) figures, line deenergized
3 & 5 (HD) figures, line energized

TABLE I

	Total	Excluding slightly damped
Unknown origin	295	272
Outside switching	29	26
Pure switching surges	101	101
Lightning surges	166	96
Combined lightning and switching	6	4
Lightning arrester discharges	40	40
Ground wire surges	68	68

Outside and Pure Switching Surges. For more convenient study, the surge data have been assembled into summary curves, two of which are shown in Fig. 10. The lower curve applies to outside switching surges and shows that of 26 surges the maximum was 1.8 times normal and that 50 per cent of them were over 1.4 times normal. Outside switching surges are classified as surges originating from switching on parts of the system other than where instruments are located. In some cases, surges were caused by switching on the secondary side of the transformers connected to the 132-kv. line. This type of surge has also been included in this curve.

The upper curve of this Fig. 10 shows the results of 101 pure switching surges with maximum recording value of 5.2 times normal. These surges have been segregated as to nature, showing 9 positive, 12 negative, and 80 highly damped. Two points of the curve have been marked, indicating the maximum recorded voltage on energizing; also on deenergizing the line. These two points were the results obtained on four separate switching tests of the Philo-Canton line, in which surges caused by energizing and deenergizing the line, as well as switching load at Newcomerstown, (the approximate half-way point of the line), were separated

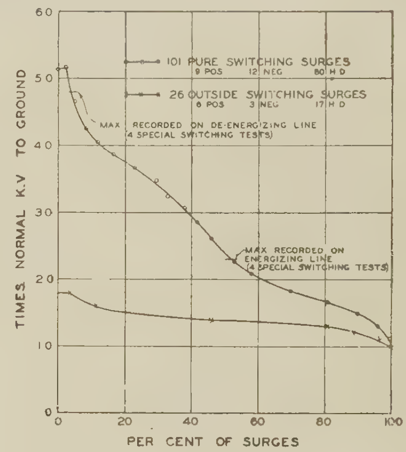

Fig. 10

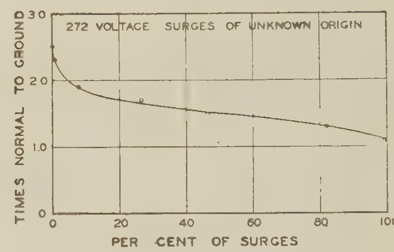

Fig. 11

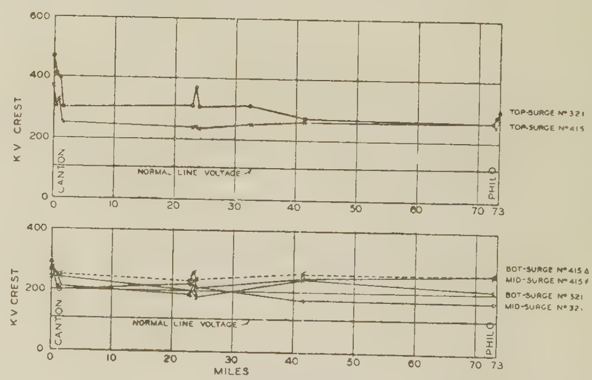

Fig. 12—Pure Line Switching Surges

May 10 to Oct. 16, 1927
Philo-Canton 132-kv. line
Deenergized at Philo station

by one-hour intervals. In the earlier part of the tests it was found that lightning and switching surges occurring at the same time caused some confusion due to the absolute impossibility of separating the switching part of the surge from the lightning part. It was therefore decided to separate the switching surges by one-hour intervals in a prearranged test, and in this way to study the effects of switching load, deenergizing the

line, and energizing the line. Results show that the maximum recorded surge occurred on deenergizing the line and was 4.8 times normal. On energizing the line, the maximum surge was 2.3 times normal.

To show the effect of the switching voltage throughout the entire length of the line, the records obtained on three of these switching surges are shown in Figs. 12 and 13. The point of interest is that the switching

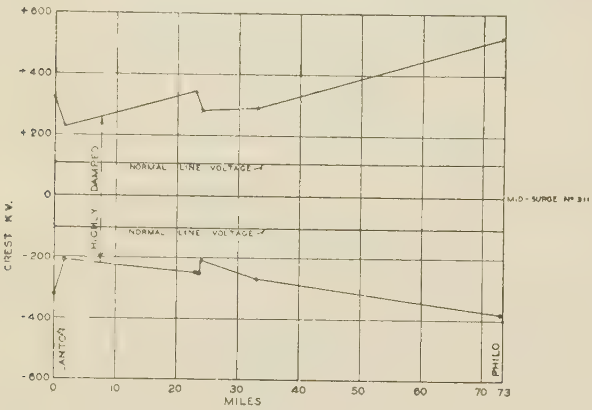

FIG. 13—PURE LINE SWITCHING SURGES

Philo-Canton 132-kv. line on July 30, 1927—11.00 p. m.
Deenergized at Canton station

surge travels with apparently little change in the voltage throughout the entire length of the line. The irregularities in the curves are probably within the limits of accuracy in the instruments, and it will be noted that the distinct tendency of higher voltages at either end of the line is due to reflection.

Surges of Unknown Origin. Surges of unknown

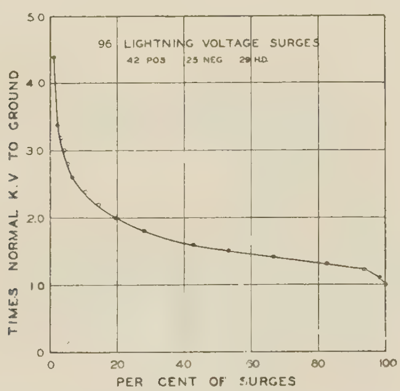

FIG. 14

origin on the Philo-Canton line are shown graphically in Fig. 11. While there were 272 surges for which no cause could be found, it will be noted that these never exceeded 2.5 times normal and only five per cent of them exceeded two times normal. This type of surge can be dismissed as being unimportant in magnitude, although constituting a comparatively large number of voltage changes on the line.

Lightning Surges. The 96 lightning surges on the Philo-Canton line are summarized in Fig. 14. The maximum surge indicated is 4.4 times normal and 50 per cent of the surges are above one and one-half times normal. These surges have been segregated as to nature predominating in each surge, as follows: 25 negative, 42 positive, and 29 highly damped.

Lightning and Lightning Surges. The four lightning surges on the line causing line trip-outs gave maximum voltages of 5.0 and 3.7 times normal to ground. These were slightly damped surges, and it is believed may have been caused by the switching surge following the lightning voltage flashover. The other two surges recorded a maximum of 5.4 and 6.2 times normal, but both being SD figures, the results were not seriously considered. Since lightning voltages more than double the values above recorded are necessary to cause insulator flashover, it is clear, even with a fairly large number of instruments on the line, that there is no certainty that anything like the maximum voltage on the line will be recorded. As sections of line in the order of 25 mi. existed where no

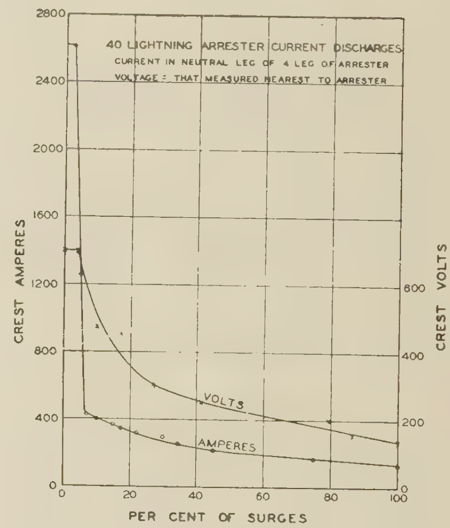

FIG. 15

surge recorder was located, this shows that the lightning voltages did not travel with destructive values any great distance. This characteristic of the lightning surge is distinctly different from the switching surge.

Voltage Drop Through Choke Coils. The attempt to measure the voltage drop through choke coils was rather ineffective on account of the existence of SD figures in the records. However, of 10 lightning surges (no SD figures included) on four surges, the bus side of the choke coil was the higher averaging nine per cent higher than the line side, and on six surges, the line side of the choke coil was higher, averaging 25½ per cent higher voltage than on the bus side. It can only be said that a tendency exists as indicated for the choke coil to reduce the lightning voltage originating on the line in the order of 25 per cent, but it is not felt that sufficient data on this subject have been obtained to finally prove the effectiveness of the choke coil.

Lightning Arrester Data. The data on all six light-

ning arresters are summarized in Fig. 15. The only record of current discharge in the arresters was obtained at Newcomerstown and Turner Substations. No records were obtained at Philo or Canton on lightning arresters due apparently to the arrester not discharging, although the instrument was set up to record a current as low as about 150 amperes in the neutral leg. In Fig. 15 it should be noted that the current and voltage are not simultaneous readings. Forty lightning arrester discharges were recorded; 21 were positive, 11 were negative, and 8 were highly damped. Of the lightning discharges, 12 were positive, eight negative, and four highly damped. Of the switching discharges, one was positive and one negative. Of the discharges due to unknown causes, nine were positive, two negative, and two highly damped. One discharge due to an arcing ground registered minus 360 and plus 410 amperes, being of a highly damped nature. An attempt to plot a curve of current against voltage recorded resulted in a shotgun curve of little value. It is felt that considerable more work will have to be done in securing lightning arrester data before any definite conclusion is arrived at.

Lightning Surges on Parallel Circuits. The data secured at instruments located on the top wires of the two Philo-Canton lines (eliminating SD figures) gave nine surges, including four positive, two negative, and three highly damped. The ratio of the two lines at any point varied from 0.80 to 1.25, averaging 1.03. The minimum voltages occurring during these surges were in the order of from 120 kv. to 140 kv. minimum to 340 to 400 kv. maximum. Here, again, the data are too meager to prove definitely that the induced voltages on the two wires are equal; but this tendency is indicated.

Tower Base Voltages. At Station 43, where an instrument was located to determine the voltage between the tower base and ground, no records were obtained during the season. It should also be noted that at this tower there were no flashovers of the line.

VIII. Conclusions

1. The choke coils reduced the recorded lightning voltage in the order of 25 per cent, although tests on this feature are not sufficiently extensive to prove this statement conclusively. Reflections at the coke coil may also have had a decided effect in altering the incoming voltage wave, so that this 25 per cent may not have been an actual reduction of the initial wave.

2. The protective value of the ground wire could not be proved conclusively from the data, due largely to the presence of SD figures in the records. It is planned to continue this investigation the coming year.

3. The record on instruments at the time of line trip-outs due to lightning (maximum 5.0 times normal voltage is found) indicates that the voltages higher than recorded must have existed on the line for flashover to have occurred. This brings up the point that surge recorders must be placed in generous numbers on a line to thoroughly study line performance. There is further indication from these data, that lightning voltages do not travel a great distance. Otherwise there would have been recorded high voltages on some of the surge recorders.

4. The polarity of lightning surges indicated a preponderance of positive impulses. Of 96 surges, 42 were positive, 25 negative, and 29 highly damped.

5. Transient voltages on the ground wire at the tower were recorded as high as 8200 volts negative during a lightning storm, and in all cases were of the order of 3000 to 4000 volts. These surges were recorded at times of lightning storms and switching; in some cases no cause could be found. This relatively lower voltage on the ground wire compared with the higher voltage on the line is positive evidence of the effectiveness of the ground wire in reducing the impulse voltages on the line itself.

6. Lightning arrester discharges in all cases were of the general order of 200 to 400 amperes, although two cases were recorded as high as 1260 and 2620 amperes. Measured currents were in all cases the sum of the currents in all three legs of the arrester. The highest recorded current was negative; the 1260 ampere value was highly damped, being initially negative.

7. Attenuation of lightning surge voltages failed to give any conclusive results chiefly on account of the presence of SD figures.

8. The attempt to determine voltage changes at the termination of the ground wire was not very successful due principally to insufficient reliable data and the proximity of the test point to the substation where the numerous changes in surge impedance introduced the question of reflected waves.

9. Switching surges have been recorded as high as 5.2 times normal, which seems to be in general agreement with previous results. Over 50 per cent of the switching surges were of the order of two and one-half times normal to ground or higher. By isolating switching surges in four special tests, it was shown that the surge voltage on deenergizing the line was approximately twice as great as on energizing the line. Switching surges are mostly of a highly damped nature, as shown by the data.

10. During the tests, no voltage was recorded between the base of a tower and ground, although the voltage at the peak of the tower to which the ground wire was attached indicated surge voltages up to 8200 volts.

11. The relative lightning voltage on parallel conductors is shown to be equal, although the data are too limited to prove this point definitely.

12. It was shown that the two types of surge recorders are equally reliable from the point of view of measuring surges; but it was also shown that the type of coupling employed to connect the instruments to the line must be carefully studied and selected or erroneous

conclusions may result. This point is clearly shown from the experience at Tower 172, Stations 20, 21, 22 and 23.

13. It is believed that this investigation has resulted in some new information, some confirmatory, and some negative. All this information is valuable, although a great deal more data must be obtained to properly solve the lightning problem. With this data and the data it is hoped will be obtained during the year 1928 lightning season, it is believed some further light will be thrown upon the lightning voltage situation.

Acknowledgment is due to various men in the organization of the General Electric Company, the Westinghouse Electric Manufacturing Company, the American Gas and Electric Company, the Ohio Power Company, and Appalachian Electric Power Company, who participated and helped in the work of this investigation.

Abridgment of

Motor Drives for Cards and Roving Frames

BY H. W. REDING[1]

Member, A. I. E. E.

Synopsis.—*Improved forms of drive for cotton cards and roving frames have until recently, received less attention than most other applications in the textile industry. In this article there is a discussion of the forms of drive available for three classes of machinery, together with a discussion of the factors which must be considered in selecting a drive under particular conditions.*

ONLY within the past few years has particular attention been paid to the development of individual motor drives for the cards and roving frames of cotton mills.

Probably the reasons for this delay are that the advantages were not recognized and the applications of individual drives were less simple than for other forms of cotton mill machinery on which individual drives have been used successfully for many years.

The carding process is the second one in the manufacture of cotton yarn. In the first process, the baled cotton is loosened, cleaned of trash to a certain extent, and delivered in the form of a lap, or rolled up sheet of loose cotton, usually 40 in. wide. The card removes still more of the dirt, and tends to straighten and parallel the individual fibers of the cotton. Stock is delivered from the card in the form of sliver or a soft strand of cotton approximately one inch in diameter.

Following the card comes the drawing process, in which multiple strands of sliver are drawn again to one strand. This doubling and drawing action tends to eliminate irregularities and further parallels the fibers.

The next are the roving processes. Two to four processes are used depending upon the product. The soft untwisted sliver is doubled and drawn to a much smaller diameter, and each process puts in a little twist. From the roving frames, the stock goes to the spinning frames, where it is finally drawn and twisted to form the yarn.

Card Application Requirements

In construction, the principal elements of a card are two heavy cast iron cylinders known, respectively, as the main cylinder and the doffer. The main cylinder is 50 in. in diameter and 40 in. wide, revolving at a speed of from 160 to 180 rev. per min. The doffer cylinder is smaller in diameter and revolves at a much lower speed. Cotton is carried by fine wire points on the surface of the main cylinder past stationary wire points, and it is this action which tends to straighten, or comb out the fibers.

Polyphase a-c. motors, rated at 1¼ to 2 hp. and 1160 rev. per min., have been adopted generally for individual card drive application, the motors being mounted on brackets attached to the cards with gear or chain drive to the main shafts. The motor is designed to have a starting torque of about 250 per cent of full-load torque, which is more than is necessary to overcome the static friction. Without this fairly high torque, the period of acceleration would be unduly long, owing to the inertia of the cylinders. As customarily installed, the starting period is from 18 to 22 sec., which has proved to be entirely satisfactory.

At times, in order that the fine wire points may be ground, it is necessary to reverse the direction of rotation. In addition, the card must be stripped from two to four times a day. This work consists in removing from the bases of the fine wire points the accumulation of cotton and dust. Naturally, the application of individual drive to a card must be capable of properly meeting the additional requirements of reversing and stripping.

Roving Frame Application Requirements

Roving frames handle stock which is in a very soft

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1. Textile Engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at the Regional Meeting of the Southern District No. 4 of the A. I. E. E., Atlanta, Ga., Oct. 29-31, 1928. Complete copies upon request.

condition. There is very little twist,—consequently, little strength—making it necessary to guard against unevenness in the application of torque.

Motor drives for roving frames fall into the two general classes of group and individual drives, and there are two types of each employed. As to group drives, there is the usual form of large group drive and the four-frame drive in which frames are belt-driven directly from pulleys on the motor shaft. Low-speed motors are used for this service.

As to individual drives, one system employs a motor which runs continuously. The frame is started and stopped by operating a clutch between the motor and the frame shaft. The other system makes use of a motor driving directly to the machine. In this case the motor must start and stop with the frame.

The foregoing discussion gives, in a brief way, the general driving requirements of carding and roving machinery and the forms of drive which are available. Let us now consider the factors which enter into the problem of selecting the form of drive to be used for any particular case.

In an old mill being changed from engine to motor drive, there are many considerations which are not involved in planning drives for a new mill or for machinery to be added to an old mill. The following discussion of factors affecting the selection of drive applies particularly to the equipment of new mills, or the addition of machinery to old ones where provision for driving must also be added.

Characteristics of Card Drives

In connection with cards, there are the two general systems of drive. In the following discussion the advantages and disadvantages of each are considered under several headings.

Speed and Production

A card with gear or chain drive will run at a constant and predetermined speed within very narrow limits. Such variations as are found are caused by slight differences in load. With belt drive, there is always the probability of slip, and while this may be overcome to a certain extent by allowing for it in calculating pulley ratios, the slip is not constant. It varies with atmospheric conditions, temperature, and condition of the belts. This causes a loss of production proportional to the degree of slip.

The results of individual drive compared with group drive, with respect to speed and production, are well illustrated by speed studies which have been made. The speed of each card was taken in a number of mills. The mills selected were all well equipped and maintained. Since ideas as to the proper speed of a card vary, the difference between the average and maximum speeds found in the same installation is taken as the measure of the loss of production.

In the group drive installations was found an average loss of 7.3 rev. per min. or 4.33 per cent.

Slight variations were found also in individual drive installations, and applying the same method of computing, the average loss was 1.1 rev. per min. or 0.59 per cent.

The difference between these two percentages, (or 3.74 per cent), is a fair measure of the increased production which may be obtained with individual drive as compared with group drive.

Flexibility

By flexibility is meant the ability to install or operate a machine at any time with a minimum of reference to other factors or conditions. Machines with individual motors may be installed without reference to a fixed shafting layout or in accordance with an arrangement which would make a difficult layout for shafting. Such machines may be operated at any time without reference to other machines and in case of failure of a motor or drive, one machine only, is affected. The question of flexibility is often a deciding factor where machinery is to be added to an old mill. With respect to flexibility the individual drive is ideal.

Floor Space and Safety

A card with individual drive will have an over-all width approximately five inches more than the same card arranged for belt drive. The spacing with individual drive depends upon opinion and local conditions, but since there is no exposed moving part in connection with the drive there may be smaller clearances between the end of a motor and the adjoining card. In practise, the space occupied by an installation of cards with individual motors will be very nearly the same as that occupied by the same number of machines driven in a group.

Regarding safety, there is unquestionably an advantage in favor of the individual drive.

Cleanliness

In this respect, individual drive is superior to group drive. Shafting and pulleys collect lint and dirt which must come down. If it drops onto the card or the stock, the quality of the output is to some extent damaged.

Appearance

In this respect, individual drive is the better. Appearance is an intangible quality, but unquestionably one of real importance where fine work is being done.

Maintenance

There is little advantage to be claimed for either system with respect to maintenance and replacement. The accessibility of the individual drive makes easy the good care which might in some cases have a bearing on the life of the equipment.

Efficiency and Power Factor

Large motors used with group drive are more efficient than small ones used with individual drive, but the drive used in the individual installation is more efficient than belts and shafting necessarily used with the larger motors. The loss in shafting and belts will vary from

12 to 35 per cent, so no general comparison may be made. When ball-bearing hangers are used on correctly alined shafting the over-all efficiency of the group drive will about equal that of the individual drive. When plain bearings are used, the difference will almost certainly be in favor of the individual drive. Assuming 95 per cent efficiency for the chain used with individual drive, and 80 per cent for the transmission used with group drive, the combined efficiency of the small motor and chain will be about 79 per cent. The combined efficiency of large motor and transmission will be about 73 per cent. The difference of 6 per cent is thus in favor of the individual drive.

The power factor of a typical group drive installation will be about 89 per cent and of a typical group of individual drives about 78 per cent.

Cost Analyses—Card Drives

With the exception of the cost element, the foregoing discussion covers the principal points to be considered in selecting a drive for a group of cards. Following are comparative estimates of cost. A card, (in place), with driving equipment is taken as a unit. The cost of the unit with individual drive may be compared with that of the unit with group drive. Against this may be balanced the effectiveness of the unit as a producing machine when driven by an individual motor, as compared with its effectiveness when group driven.

Card with Individual Drive:		
1—40-in. card delivered and erected	$1000	
Floor space occupied at $2.00 per sq. ft.	190	
1—Individual card motor with switch, bracket, drive, guard, delivery, wiring and installation	158	
Total		$1348
Card with Group Drive:		
1—40-in. card delivered and erected	$1000	
Floor space occupied at $2.00 per sq. ft.	180	
Cost per card of group drive, including motor, switch, wiring, belting, pulleys, shafting, freight, and installation	63	
Total		$1243
Difference		$ 105

This difference takes into account the slight additional floor space often allowed for individual drive.

These figures indicate that a saving of 7.8 per cent in first cost may be made by installing group drive and translated into terms of annual fixed charges at 12 per cent means an additonal cost of $12.60 per year for each card.

On the other hand, the individual drive will handle at least 3 to 5 per cent more stock with given adjustment of machine and speed. This increase comes with no increased labor cost, and may result in a reduction of the number of cards installed for a required output from the carding department. Also, there is the item of power consumption. In most cases the difference in efficiency will be in favor of individual drive. In any particular case, these factors may be directly translated into annual savings. In addition, there are important intangible advantages credited to individual drive, such as cleanliness, flexibility, convenience, appearance, and safety. These are more difficult to translate into dollars per year, but each one has a definite value in a mill where quality of output is important. Each card will handle stock valued at from $6000 to $7000 in a year, based on which, these intangible qualities operate to offset the additional yearly fixed charge of $12.60, which is directly chargeable to individual drive.

Roving Frame Drive Characteristics

In connection with drives for roving frames, the factors to be considered in selecting a drive are, in many ways, similar to those discussed above with regard to cards, except that there are three alternatives instead of two. A discussion of the relative merits of the three systems follows.

Production

Production of roving machinery in general depends upon a proper application of power and constant and correct speed.

A positive individual drive, if properly applied, will deliver a flow of power which will not cause the ends to break and which will hold a constant and predetermined speed. These conditions assure maximum production from each machine so far as is possible with respect to the drive.

With group drive, there is an average of three belts between the motor and the machine. The possibility of variable slip in each of these drives tends to reduce production.

Four-frame drive decreases the number of belts to one, and has a record of satisfactory service. There remains the possible slip in the one-belt, in addition to which there is the question of wear of the non-metallic pulleys used on the motors. These pulleys are comparatively small in diameter and with wear on the surface, the speed is reduced. If we assume that a pulley wears down 1/8 in., in the course of several years, there will be an average loss of production over this period of at least 1½ per cent.

Flexibility

As to flexibility in operation, from a practical standpoint, the four-frame and the individual systems of drive are about equal. The four-frame drive is not suitable unless there is good ceiling height. Failure of one motor stops four frames, while with individual drive, only one would be affected.

The group drive system naturally lacks flexibility.

Cleanliness

In respect to cleanliness, the individual drive possesses distinct advantages over the other forms of drive. There is no possibility of oil drip, and there is much

less probability of flying bits of lint alighting on the work. A little accumulation of lint being caught in the roving tends to make an enlarged place in the yarn, which, for even work, must not occur.

The four-frame drive is superior in this respect to the group drive, but is inferior to the individual drive.

Efficiency and Power Factor

The difference between individual and four-frame drive will be slight with regard to efficiency and power factor. Group drive will be lower in efficiency. Typical efficiencies would be 81 per cent, 80 per cent and 73 per cent for individual, four-frame, and group drives, respectively, including the loss in drives as well as in motors. Similarly, power factors would be 84 per cent, 80 per cent and 91 per cent.

Appearance

The remarks concerning appearance in regard to card drives apply with equal force to roving frame drives.

Cost Analysis—Roving Frames

The cost analysis of roving frames is not quite so simple as that of cards, since size and capacity vary widely. As a reasonable average, let us consider a 9 in. by 4½ in., 114-spindle intermediate frame with the various types of drive which may be applied.

Cost of Frame

1—114 sp. intermediate frame delivered and erected	$1900
230 sq. ft. of floor space at $2.00	460
Total	$2360

Cost of Drive Per Frame

I

Group drive (based upon a group of 16 frames) including motor, switch, wiring, shafting, belts, pulleys, delivery and erection.......... $ 78.60

II

Four-frame drive including motor, switch, belts, delivery and erection.......... $ 86.75

III

Individual drive without clutch including motor, switches, wiring, bracket, chain, delivery and erection.......... $169.75

IV

Individual drive with clutch including motor, switch, wiring, clutch, bracket, delivery and erection.......... $214.40

Summary

	Cost of frame and drive	Per cent more than I	Per cent more than II
Frame and drive I	$2438.60	0	
Frame and drive II	2446.75	0.3	0
Frame and drive III	2529.75	3.7	3.4
Frame and drive IV	2574.40	5.6	5.2

Fixed charges on the additional investment in individual drive will range from $10 to $16 per year for one frame and the value of the cotton handled in a year will be from $30,000 to $50,000. Even very small values placed upon the improvements in quality and production which are attributable to individual drive will very quickly offset the added cost of such drive.

Summary

To sum up the situation with respect to card drives, the individual drive excels in regard to more uniform speed and greater production, cleanliness, flexibility, convenience, appearance, safety, and usually better efficiency.

Group drive has the advantages of slightly less floor space, better power factor, and lower first cost.

With respect to roving frames, individual drive has these advantages of over either four-frame or large group drive; more uniform speed and greater production, cleanliness, flexibility, appearance, and safety.

Four-frame drive may claim better speed and production than the large group, flexibility practically equal to individual drive, better appearance and cleanliness than the large group, and lower first cost than individual drive.

Large group drive may claim low first cost.

Conclusion

From this analysis, it is evident that individual drive provides to the greatest degree the qualities which are desirable from a manufacturing standpoint. The principal claim of the other forms of drive is lower first cost which is typical of group drive for industrial applications generally. As is seen above, the difference between the cost of a card equipped with individual drive is a very small percentage more than the same card with a group drive and the fixed charges on this additional cost is negligible in comparison with the value of the stock handled in the course of a year.

The experience of those who have used individual drives or cards and roving make it clear that the value of the qualities peculiar to individual drive may greatly exceed the small difference in first cost and lead to the conclusion that this form of drive will be increasingly used by those making high quality cotton yarn and cloth.

WORLD'S LARGEST ELECTRIC LAMP

The world's largest electric lamp, a monster 50,000 watt experimental bulb built recently is like a radio tube in apperance. At the top of the bulb, a radiator made of metal fins carries off intense heat generated by the white-hot tungsten filament, which has a temperature of 5500 deg. fahr.—twice as hot as molten steel. The bulb is filled with nitrogen gas, whose circulation cools it and carries upward into the radiator evaporated or thrown-off tungsten particles from the filament, thus preventing blackening of the walls.

Although the present lamp is intended simply for a test by its designer such huge lights ultimately may find use in airport lighting and for the illumination of motion picture studios.—*Transactions I. E. S.*

Abridgment of

Selection of Motor Equipment by Principle of Similar Speed-Time Curves

BY BERNDT A. WIDELL, JR.[1]

Member, A. I. E. E.

Synopsis.—Data for making preliminary estimates of speed of cars required, and capacity of motor to do a given service have been rather limited. The object of this paper is to show a method whereby it is possible to provide curves which are simple to calculate and easy to apply.

No mathematical formula has ever been derived to express the speed–time or current–time curves for a railway motor. Similarity between speed–time curves has been resorted to and this paper shows how this method can be used to give very accurate results by proper consideration of the various factors which influence the shape of the speed–time curve.

Previous methods for estimating motor capacities are based on the horsepower of motor required, but with the advent of the self-ventilated and blown motors it is necessary to calculate the r. m. s. current for a given cycle and select a motor having this continuous rating. A method for doing this is proposed, based on similar current–time curves.

The limiting values of average running speeds for given rates of acceleration and braking, and the data for obtaining motor capacity necessary at these limits are indicated on each curve. This helps one to visualize why it is not practicable to perform certain schedules on a fixed rate of acceleration and braking basis.

ONE of the most complicated engineering problems is that of selecting the proper motor equipment to perform a given railway service. By "service" we mean that cars must make a given number of stops and slowdowns over a route in a given time. In many instances, the profile of the route is hilly and voltage varies on different sections of the route, thus making it necessary to consider small sections of road at a time in our calculations to arrive at a suitable motor equipment. As a first approximation, it is usually assumed that the route is absolutely level. An average line voltage is also assumed, thereby reducing the work to a few simple speed–time curves. In the majority of cases, such a solution is accurate enough, but if it is not, sufficient information has been obtained to shorten the work of making detailed calculations over the entire profile as it actually exists and for the varying line voltages.

Several electric railway engineers (among them E. H. Anderson, A. H. Armstrong and F. W. Carter) have plotted curves from which a rough approximation of the speed of equipment necessary to do a certain service can be made. Realizing that much more accurate curves could be plotted to cover greater ground, an investigation was made which showed that the car friction and slope of the motor speed–tractive-effort curve were the factors which most influenced the shape of the speed–time curve, and hence the schedule speed, for a given rate of braking and acceleration. Referring to Fig. 1, curves *B* and *C* are speed–time curves for a certain weight of car, making the same schedule speed for the same length of run. The speed on leaving control and free running speed are shown in the table. It should be noted that for the same value of car friction, there is a 5.5 per cent difference between speeds on leaving control, and 7 per cent difference between free running speeds, due to different motor characteristics alone. Comparing curve *C* with *A*, the difference between speeds on leaving control and free running speeds is 15 per cent and 19 per cent, respectively.

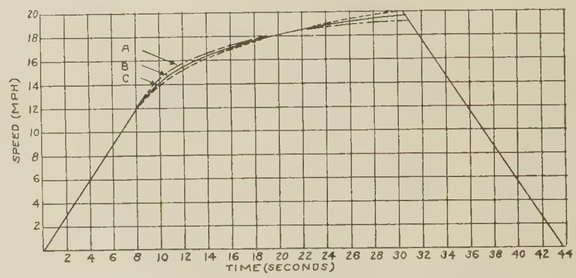

Fig. 1—Speed–Time Curves Illustrating the Differences in Shape Due to the Slope of Speed–Tractive-Effort Curve and the Car Friction

A—Average motor characteristic, friction 40 lb. per ton
B—Flat motor characteristic, friction 20 lb. per ton
C—Steep motor characteristic, friction 20 lb. per ton

Speed on leaving control (mi. per hr.)	A—12.9,	B—11.8,	C—11.2
Free running speed (mi. per hr.)	A—20.1,	B—22.3,	C—23.9

Conditions: Length of run, 830 ft. rate of acceleration and braking 1.5 mi. per hr. per sec.; average running speed 12.96 mi. per hr.; constant car friction

Obviously, if we are to make up curves that are to possess any degree of accuracy, the car friction and slope of speed–tractive-effort curve must be considered.

First let us consider the effect of the slope of motor characteristic on the schedule speed. In order to distinguish between two different motor characteristics, the one whose speed–tractive-effort curve has the greatest slope is termed steep, whereas, that with the less slope, is flat. Fig. 2 illustrates the difference in the two motors' characteristics. Referring to Fig. 3 and assuming that the number of stops per mile being made as one, we can read the free running speed corre-

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sponding to the average running speed directly. With an equipment geared to 75 mi. per hr., the following average running speeds can be made with a motor having the steepest and flattest characteristic respectively 34.6 mi. per hr. and 35.3 mi. per hr.—a difference of 2 per cent. Over the usable part of this curve, the maximum variation in average running speed, due to the slope of motor characteristic is 2 per cent. If

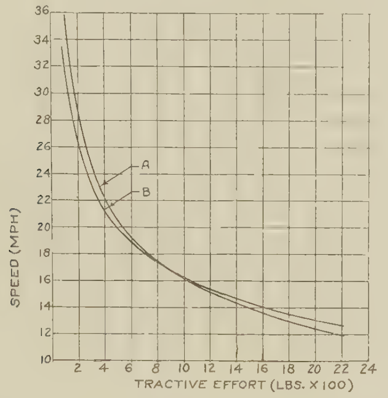

Fig. 2—Speed–Tractive-Effort Curve of Two Motors Having a Difference in Slope

A—Steep motor characteristic
B—Flat motor characteristic

we base the curves on an average motor characteristic as indicated, the maximum variation in average running speed from either steep or flat characteristic is about 1.4 per cent.

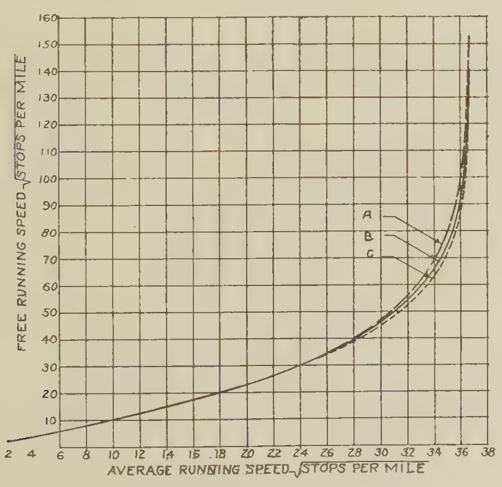

Fig. 3—Curves Illustrating the Different Free Running Speeds Required for Motors Having Different Slope Speed–Tractive-Effort Curves

Conditions: Rate of acceleration and braking 1.5 mi. per hr. per sec. Constant car friction 20 lb. per ton. No coasting, no leeway

A—Steep motor characteristic
B—Average motor characteristic
C—Flat motor characteristic

Next let us consider the effect of car friction on the average running speed. Referring to Fig. 4, a series of curves has been plotted using an average motor characteristic as determined in the above paragraphs. With a 75-mi. per hr. equipment, the average running speeds that can be made with car friction of 10, 20, 30 and 40 lb. per ton are 33.6, 35.0, 35.5 and 36.0 mi. per hr. respectively. Practically all other curves of a similar nature have been based on 20 lb. per ton friction; hence, the error where the actual friction is 10 lb. per ton is 4.2 per cent, for 30 lb. per ton friction 1.5 per cent, and for 40 lb. per ton friction 2.8 per cent. We can eliminate this error by using the average motor characteristic and plotting curves for the various friction values encountered, in which case the maximum error in average running speed calculated from these curves should not exceed 1.4 per cent.

The method by which curves of Fig. 3 and Fig. 4 were calculated is a development of the similar speed–time curve idea. For instance, if speed–time curves

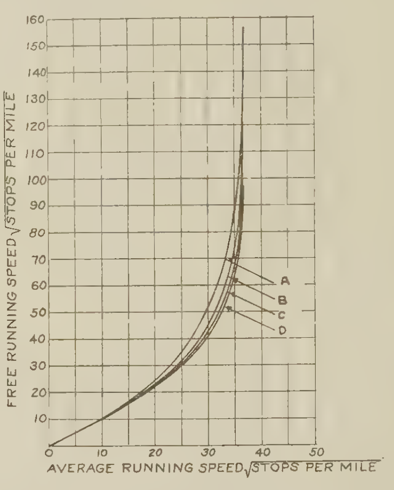

Fig. 4—Curves Illustrating the Different Free Running Speeds Required with a Motor Having an Average Slope Speed–Tractive-Effort Curve for Various Car Friction Values

Conditions: Rate of acceleration and braking 1.5 mi. per hr. per sec.; no coasting; no leeway; car friction constant at values given:
A—10 lb. per ton car friction, B—20, C—30, D—40

Use: Abscissas are the values of average running speed times √ stops per mile, and corresponding values of ordinate on friction curve divided by the √ stops per mile gives the free running speeds necessary to make the average running speed

are calculated using the average characteristic and a given rate of acceleration and braking for different lengths of run, a series of different shaped speed–time curves is obtained. The shortest run will be represented by a triangle, a slightly longer run will show the car accelerating according to the slope of motor characteristic and value of car friction, and the longest run will be practically at free running speed. If a means is obtained for expressing each of these speed–time curves in terms of similar speed–time curves to give greater or less distance traversed, it will be possible to represent ever existing running condition. How this is accomplished can best be explained by referring to Fig. 5.

Let D_1 = distance traveled in t_1 seconds.
D_2 = distance traveled in t_2 seconds.

On an assumption that the two curves are similar, the following relations are true:

$$\frac{D_1}{D_2} = \left(\frac{S_1}{S_3}\right)^2 = \left(\frac{t_1}{t_2}\right)^2 = \left(\frac{V_1}{V_2}\right)^2 = \left(\frac{S_2}{S_4}\right)^2$$

where $V_1 = \dfrac{D_1}{t_1}$ and $V_2 = \dfrac{D_2}{t_2}$ = average running speed

or since $D_1 = \dfrac{5280}{\text{stops per mile}_1}$ and $D_2 = \dfrac{5280}{\text{stops per mile}_2}$

we can write $\dfrac{\text{stops per mile}_2}{\text{stops per mile}_1} = \left(\dfrac{S_1}{S_3}\right)^2 = \left(\dfrac{t_1}{t_2}\right)^2$

$$= \left(\frac{V_1}{V_2}\right)^2 = \left(\frac{S_2}{S_4}\right)^2.$$

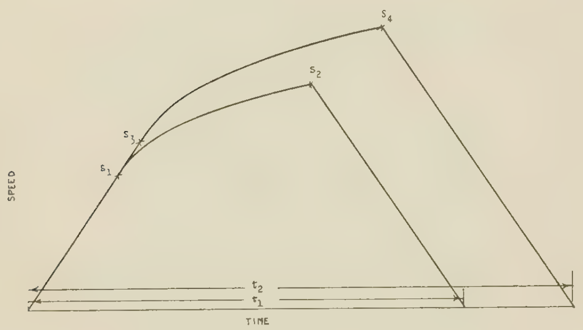

Fig. 5—Similar Speed-Time Curves

And by transposition, using an abbreviation of stop per mile S/M,

$$S/M_1\, S_1^2 = S/M_2\, S_3^2$$

or $$\sqrt{S/M_1}\, S_1 = \sqrt{S/M_2}\, S_3 \quad (1)$$

and similarly $$\sqrt{S/M_1}\, V_1 = \sqrt{S/M_2}\, V_2 \quad (2)$$

$$\sqrt{S/M_1}\, t_1 = \sqrt{S/M_2}\, t_2 \quad (3)$$

$$\sqrt{S/M_1}\, S_2 = \sqrt{S/M_2}\, S_4 \quad (4)$$

Referring back to the different shaped speed-time curves, we can calculate $\sqrt{S/M_1}\, S_1$ and $\sqrt{S/M_1}\, V_1$ for each speed-time curve and plot a curve of (average running speed) times $\sqrt{\text{stops per mile}}$ against (speed on leaving control) times $\sqrt{\text{stops per mile}}$. S_1 of Fig. 6 shows such a curve based on the average characteristic. The value of S_1 is the product of (speed on leaving control) times $\sqrt{\text{stops per mile}}$. There is also shown a S_2 curve, the value of S_2 being (speed at which braking starts) times $\sqrt{\text{stops per mile}}$.

Thus, knowing the schedule speed required and the average length of run, the speed on leaving control can be calculated from Fig. 6 and a motor selected with a gear ratio such that it will have this speed at the tractive effort necessary to accelerate the car at the desired rate and at the average line voltage. However, this curve (Fig. 6) is not applicable to the tapped field motor because the speed on leaving control resistance points is quite different for a tapped and full field motor when both motors are geared to make the same free running speed. In view of the fact that a tapped field motor will make practically the same schedule speed as a full field motor, each having the same free running speed, and also to the fact that the free running speed of a full

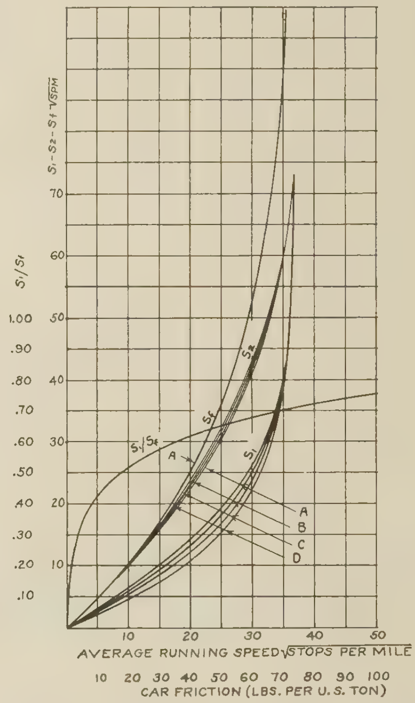

Fig. 6—Curves for Estimating Speed at End of Acceleration, Speed at Instant of Braking, and Free Running Speed

S_1—Speed at end of acceleration times $\sqrt{\text{stops per mile}}$
S_1/S_f—Ratio of speed at end of acceleration to free running speed
S_2—Speed at which braking commences times $\sqrt{\text{stops per mile}}$
S_f—Free running speed times $\sqrt{\text{stops per mile}}$

A—10 lb. per ton car friction
B—20 lb. per ton car friction
C—30 lb. per ton car friction
D—40 lb. per ton car friction

Conditions: Rates of acceleration and braking 1.5 mi. per hr. per sec.; no coasting; no leeway; car friction constant at values given

Use: For a given value of abscissas; the free running speed is equal to value of ordinate S_1 divided by the value of ordinate S_1/S_f for proper car friction value and by $\sqrt{\text{stops per mile}}$, or to the value of ordinate S_f divided by the $\sqrt{\text{stops per mile}}$; the speed at instant of braking is the value of ordinate S_2 divided by the $\sqrt{\text{stops per mile}}$

field motor can be expressed accurately in terms of the speed on leaving control, a more practicable set of curves has been calculated showing the relation between (average running speed) $\sqrt{\text{stops per mile}}$ and (free running speed) $\sqrt{\text{stops per mile}}$.

The method of expressing the free running speed in terms of the speed on leaving control was suggested by Mr. E. E. Kimball's discussion of Professor Woodruff's paper presented before the A. I. E. E. Nov. 13, 1914. Mr. Kimball noted that the tractive effort had a

logarithmic relationship to speed and therefore, that knowing the speed at one value of tractive effort, the speed could be calculated for any other value of tractive effort by the following equation:

$$S = S_0 \sqrt[3]{\frac{P_0}{P}} \qquad (5)$$

Where S = speed at tractive effort P
S_0 = speed at tractive effort P_0

The cube root factor in Equation (5) represents the slope of the speed—tractive-effort curve and, as stated by Mr. Kimball, was selected because of the ease of making certain calculations. The variation in this slope factor was determined by plotting on logarithmic paper speed against tractive effort for several motors varying in capacity. In the majority of cases the resultant curves were perfectly straight throughout the range of voltage and current at which the motors would be normally used. Therefore, the logarithmic relationship

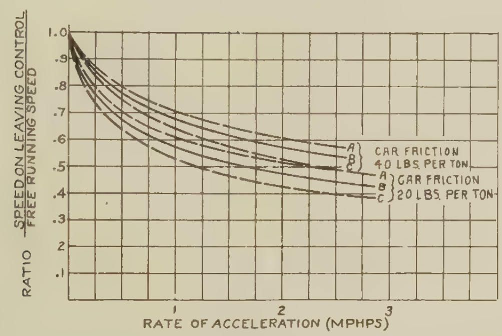

Fig. 7—Curves Illustrating Change in Ratio of Speed on Leaving Control to Free Running Speed with Various Values of Accelerating Rates, Car Friction, and Slope of Motor Speed Tractive Effort Curves

A—Flat motor characteristic
B—Average motor characteristic
C—Steep motor characteristic

Formula $$\frac{S_1}{S_f} = \sqrt[A]{\frac{p}{P}}$$

Where S_f = Free running speed mi. per hr.
S_1 = Speed on leaving control mi. per hr.
A = Exponent expressing relationship between tractive effort and speed of motor characteristic
p = Car friction at free running speed (lb. per ton)
P = Tractive effort required to accelerate car at a given rate (lb. per ton)

between speed and tractive effort can be expressed by the following equation.

$$T\,E \text{ times } S^a = K \qquad (6)$$

where $T\,E$ = tractive effort (lb.)
S = speed mi. per hr.
a = exponent determined from plot (slope factor)
K = constant determined from plot

The values of (a) varied between 2.8 and 3.5 representing respectively the steepest and flattest motor characteristics. A motor characteristic having a slope factor of 3.2 represents the average slope of all motors considered and is that used as a basis of these curves.

Equation (5) shows that the ratio of speed on leaving control to free running speed depends on the slope of speed tractive effort curve, the car friction and the rate of acceleration. Fig. 7 shows the variation of this ratio according to Equation (5).

A set of curves based on different rates of acceleration

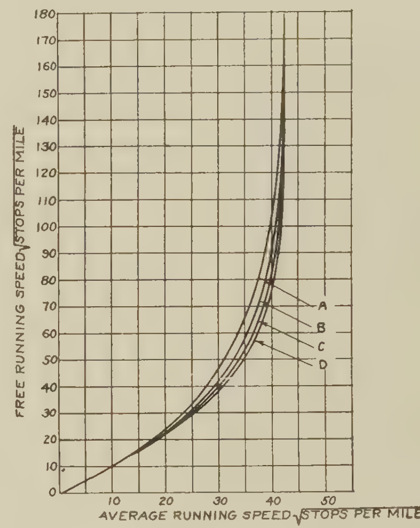

Fig. 9—Curves for Estimating Free Running Speeds

Conditions: Rate of acceleration and braking 2.0 mi. per hr. per sec. No coasting, no leeway, car friction constant for values given

A—10 lb. per ton car friction, B—20, C—30, D—40

Use: Abscissas are the values of average running speed times √ stops per mile and corresponding values of ordinate on friction curve divided by the √ stops per mile gives the free running speed necessary to make the average running speed

and braking encountered in normal train operation of (average running speed) √ stops per mile against (free running speed) √ stops per mile gives a ready means for determining the rates of acceleration and braking required and the free running speed necessary with those rates to make a given average running speed. Figs. 4 and 9 show the character of such curves covering normal street car conditions.

ELECTRIC LIGHT FOR LOUVRE GALLERIES

The art collections in the Louvre galleries in Paris, which have been in semi-darkness during the winter, will be adequately lighted in future by means of an elaborate electric lighting system which has just been placed in operation. The proposal to light the Louvre by electricity has been opposed on the ground of fire risk, but following the successful use of electricity in the National Library, which houses the most valuable national manuscripts, the Louvre authorities decided to adopt modern lighting methods.

Abridgment of

General Power Applications

ANNUAL REPORT OF COMMITTEE ON GENERAL POWER APPLICATIONS*

To the Board of Directors:

Only the following excerpts from the Committee's Report are noted here. For the detailed report on these and other applications, and of further Committee activities, reference should be made to the full report.

Marine Equipment

At the close of the year 1927 there had been placed in commission, or under construction, a total of 118 electrically-propelled vessels of various types. The equipment for these craft aggregated more than 700,000 shaft hp., about 92 per cent of the primary power being supplied by turbines, and 8 per cent by Diesel engines.

The outstanding event of the year was the completion and installation of turbine-electric propelling equipment for the Panama-Pacific Liner *California*, a twin-screw ship with a displacement of 30,250 tons at load draft.

The propelling equipment comprises two 16-stage steam-turbo generators. This power is transmitted to the propeller shafts by means of two synchronous induction type motors, having a continuous maximum rating of 8500 shaft hp. at 120 rev. per min. These motors are direct-connected to the propeller shafts and are reversible, so that no reversing turbines are required.

Diesel Electric. There have been a number of notable applications of Diesel-electric drive for marine work. One of these, in which d-c. apparatus is used, is the Coast Guard Cutter Northland, now serving on patrol in Alaskan waters.

The main engine-room equipment consists of two Diesel engine-driven generators. These supply current to a double-unit type, shunt-wound propeller motor. Each section of this motor is rated 500 hp. at 120 rev. per min. The ship will develop a speed of 12 knots with her single propeller operating at 120 rev. per min., and the motor developing 1000 shaft hp.

Other applications of Diesel-electric drive include four large double-end Diesel-electric ferry boats made for the Southern Pacific Company for service in San Francisco Bay, electrically-propelled packet boats running between points in and around New York Harbor, and cargo boats recently open to Diesel-electric propulsion by the U. S. Shipping Board.

U. S. Navy

A notable application is that of a 200-hp. 5000-rev. per min. d-c. motor on which the Navy Department recently completed tests. This motor is used to drive a three-phase blower type compressor having a capacity of 3200 cu. ft. and a discharge pressure of 10 lb. Special precautions had to be taken to balance this armature, the peripheral speed of which is approximately 20,000 ft. per min. The bearings are flood-lubricated, the oil being supplied by a separate motor-driven pump. The method of cooling is novel, the cooling air being that which is drawn through the motor into the first stage of the compressor.

Electric Railways

Oil-Electric Locomotives. Two 100-ton units are now in heavy switching service on the Erie Railroad, and 60-ton units were completed for the Chicago & Northwestern Railway, the Union Carbide Co. and the American Rolling Mills Company. Work is also proceeding on oil-electric freight and passenger locomotives for the Putnam Division of the New York Central Railroad, and a 300-hp. oil-electric motor car is ready for service.

Gas-Electric Motor Cars. One of the large automotive truck manufacturing concerns has announced the completion of car units, consisting of gasoline engines and electric generators, to be used with an electric drive to furnish power for virtually any kind of transportation.

Special Type Locomotives. A new combination trolley and storage battery type of locomotive has been placed in service by the Chicago, North Shore and Milwaukee R. R. These locomotives may be used either on the trolley system, or on tracks not now equipped with trolleys. D-c. control is provided for either trolley or battery, and transfer from trolley to battery power is automatic.

Automatic Substations for Railway Signaling Power Supply. The continuous inductive type of automatic train control provides a new field for the application of small frequency-changing motor-generator sets and automatic control for starting the sets and for connecting the generators to the load in the shortest time possible. Power is supplied to the train control system at a frequency of 100 cycles in order to eliminate inductive interference from commercial circuits.

Motor-generator sets provide the 100-cycle power from 25- or 60-cycle primary sources. The motor-

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*COMMITTEE ON GENERAL POWER APPLICATIONS:

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Presented at the Summer Convention of the A. I. E. E., at Denver, Colo., June 25-29, 1928. Complete copies upon request.

generator sets range in size from 1.5 kv-a. to 60 kv-a. The rating depends primarily upon whether the power is to be used for both automatic train control and automatic block signaling, or only for the former.

Mining Industry

A new type "sealed equipment" cable-reel gathering locomotive has been provided for mine application and is provided with two 30-hp. motors, contactor control of the progressive series parallel type, and a motor-driven cable reel. The traction motors, the cable-reel motor, cable-reel collector rings, control, headlights, and all parts of the equipment with the exception of the trolley pole and the reel cable are completely enclosed in strong cases which are designed to prevent any gas explosions occurring within these cases being transmitted to the surrounding atmosphere.

Quarry Locomotive Cars. An interesting system of remote control for locomotive cars operating on quarry tracks was developed. With this system, a single operator is able to start, stop, and even switch cars on different tracks. Electrical equipment of the cars consists of high-torque squirrel-cage motors provided with solenoid brakes and controlled through a pair of reversing contactors which throw the motors on the line at full voltage.

Largest Hoist Motor in Western Hemisphere. One of the large electrical manufacturing companies is building for the Frood Mines of the International Nickel Company of Canada, a 3200-hp. 79-rev. per min. d-c. hoist motor. On both the horsepower and torque rating, this motor is larger than any single mine hoist motor yet installed or selected for mine hoist applications in this hemisphere.

This equipment will employ the variable-voltage d-c. system of speed control.

Improved Equipment for Gaseous Mines. In order to prevent a gas explosion communicating with the coal dust, the latter is covered with rock dust which is distributed to the walls, roof, and bottom of the mine under air pressure. A machine is used for this purpose. The rock dust is contained in the hopper at one end of the machine and is distributed by the motor-driven blower.

The electrical equipment is especially designed for use in gaseous mines and has been approved by the Bureau of Mines for this application. It consists of a 20-hp. permissible type motor and control.

The Largest Mine Locomotive. The largest single-unit underground mine locomotive was exhibited at the American Mining Congress Convention in May. This locomotive weighs 38 tons and has the following limiting dimensions: Gage 35 in., height 46 in., width 64½ in., over-all length 24 ft. The locomotive is equipped with three 133-hp., 500-volt motors, or a total of 399 hp. per locomotive. The motors are arranged for forced ventilation from a separate blower motor. The control is of the semi-magnetic type, series-parallel with overload relay and no-voltage protection.

Glass Industry

The excessive demand of thin plate glass of the non-shattering type, and for ordinary thin plate, such as used in the auto and allied industries, has caused a general building and rebuilding program for this type of glass manufacturing.

The use of electrically-driven mechanisms at practically every step has created a great and growing demand for motors, controllers, and general equipment to improve the methods of manufacture of thin plate glass.

Electrical Refrigeration

The enormous growth of motor application in the field of electrical refrigeration is indicated by the fact that ten years ago this industry produced about 1200 units a year, whereas the year 1927 produced 1,500,000 units.

An interesting application in this field is the use of single-phase motors mounted in rubber. The base of the mounting has vertical supports going up through the ventilating holes in the bottom of the end-flanges of the motor and offset around the shaft so that the top of the support is directly over the shaft and some distance above it. There are two holes in each support, one above and one below the shaft, with rubber bushings in these holes. Two pins extending inward from the end-flange engage these rubber bushed holes and support the motor. The motor is thus supported entirely from these pins in the end-flange and there are no metal-to-metal contacts between the motor and its mounting.

In this field also, it is interesting to note the application of what is essentially a two-phase motor from a single-phase line, one phase of the motor being connected directly across the source of supply and the other phase connected in parallel with the first phase through a capacitor. Due to the fact that it has no commutator or brushes, it is extremely quiet, and causes no radio interference. The motor operates as a polyphase motor and eliminates the characteristic hum of a true single-phase motor.

Paper Mill Industry

A new application to the manufacture of paper is that of an adjustable speed motor to a paper winder. This drive consists of a direct-connected variable-speed motor and the necessary control equipment. The motor is designed to give a speed range of 4 to 1 by voltage control, and to give a crawling speed of threading the paper by means of armature resistance. This particular drive was supplied at the mill of the Fraser Co., Ltd., at Madawaska, Maine.

Electric Furnaces

The brass industry as a whole uses comparatively small melting units, 75- to 200-kv-a., all single-phase. There appears to be less objection than formerly on the

part of public utility systems to single-phase loads of this character, and units as large as 300-kv-a. have been installed.

In the steel industry, the use of the three-phase arc furnace of the three-electrode type followed the standard practise of the last two or three years, and "electric steel" has now become a trade mark to indicate a superior quality of steel.

Steel Mill Industry

Automatic Steel Mill. A great improvement in the rolling of steel was inaugurated during 1927 making it possible to roll the H-shaped beam so desirable for columns in buildings. The improvement consists in using sets of rolls to simultaneously roll the flanges and web of the beam. The adjustments of all of the rolls are made automatically at the same time. Important new features were also developed for the motor driving these rolls.

Automatic control is provided, permitting a single operator to control the operation of the two motors, the three screw-down motors, and the several table conveyor and transfer motors. By means of a plug-in board, the ratio of the speeds of the two reversing roll motors is predetermined and selected for each pass, and the screw-down setting of each set of rolls is selected for each pass. During operation, the attendant advances a multi-point master switch one position after each pass, and the control functions automatically to adjust the ratio of roll motor speeds and to set each of the sets of rolls, ready for the next pass.

Mill for Wide Flanged Beams. Another large equipment of unusual interest was placed in operation at the Lackawanna Plant of the Bethlehem Steel Company. The mill to which the motors were applied is used to produce wide flange beams. It consists of three units; a 54-in. reversing blooming mill, a 48-in. intermediate mill, and a 48-in. finishing mill.

Another noteworthy application at the Lackawanna Plant of the Bethlehem Steel Company is the change of the layout of the rail mill which is now being made. The 44-in, reversing blooming mill will have a driving motor rated at 7000 hp. continuously, with a 50-deg. rise and at 50/120 rev. per min.

Use of Synchronous Motors in Steel Mills. The increase in the use of synchronous motors for main roll drives in the past year is noteworthy. The new applications for the year include a 5000-hp. 40-deg. 1000-rev. per min. 2200-volt motor used to drive a 19-in. continuous sheet bar mill at the Kokomo Plant of the Continental Steel Corp., Indiana. A motor of the same horsepower rating, but at 240 rev. per min., will be used to drive a 51-in. piercing mill installed by the Standard Seamless Tube Company, of Economy, Pa. Other motors are applied to copper and brass rolling mills.

Motor Rollers. The first applications of rollers of the type, in which the driving motor is inside the roller and made integral with it, were made in the past year. These applications include motor rollers on four different parts of a continuous sheet mill at the plant of the American Sheet & Tin Plate Company, Gary, Indiana. These rollers are of different capacities and speeds, and vary from 5 to 35 cycles per sec.

Another application of these rollers is that at the Lorain Plant of the National Tube Company. Applications here include motor rollers on a runout table for conveying the rounds from the furnace to the piercing mill. Others are used to feed the pipes to and from the threading machines, (this installation being entirely automatic), and still others, for conveying the tubes through the oiling machines. All of the rollers for the National Tube Company are made of a special form to accomodate the round stock.

Oil Industry

A very good résumé of the operation of an electrically-operated oil field is given in the *Electrical World* under date of February 4, 1928.

Application of Electricity to Pipe Line Pumping. Recently electric power has been used for pumping oil through pipe lines to replace the slow-speed plunger pumps driven by steam engines or occasionally a Diesel engine, on account of their very high first cost.

In the summer of 1927, the Illinois Pipe Line Company put in booster stations using motor-driven centrifugal pumps at intermediate points between the steam stations. One pump only is required to operate in each station, a second unit acting as a stand by. Magnetic pushbutton starters of the auto-transformer types are used throughout, with pressure gages arranged to shut down the motors in case of low or excess pressures.

Electrical Welding

There was a marked advance in the application of electrical welding during the past year, both for the fabrication of electrical machines of all sizes and for the fabrication of structural beams and pieces necessary in the building industry.

The use of welded frames is rapidly becoming universal because of the great saving in weight which can be accomplished by this method.

First Arc-Welded Railway Bridge. The first arc-welded bridge of the through-girder type spans Thompson's Run, having a span of 53 ft. 9 in., although the bridge is 62 ft. 4 in, over all in length. There are 20 tons of steel in the structure and the main side girders each contain approximately 6 tons of steel.

The first arc-welded railroad bridge of the through-truss type was completed before it was moved into position on the abuttments across the canal at Westinghouse Electric & Mfg. Company's Chicopee Falls Plant. (Mass.)

Owing to the layout of the railroad facilities, the bridge is required to cross the canal at an acute angle.

The trusses are approximately 135 ft. long and the overall length of the bridge is approximately 175 ft.

The outstanding feature of interest in the design of the bridge is the fact that the welded design requires 80 tons of steel, whereas the riveted design, prepared by the railroad engineers, required 120 tons of steel. Also, the connecting material in the case of the welded bridge runs less than 5 per cent of the weight of the structure, whereas in the case of the riveted design, the weight of the connecting material is almost 30 per cent of the weight of the total structure.

Atomic-Hydrogen Arc Welding. Development work on atomic-hydrogen arc welding was completed, and a commercial equipment has been produced for use on 60-cycle circuits.

With this method of arc welding, an alternating current is maintained between adjustable tungsten wire electrodes, and hydrogen is fed to the arc around the electrodes. The hydrogen molecules are broken up into atoms by the intense heat and in recombining outside of the arc and in contact with the work, heat is liberated far in excess of that obtainable by any gas flame alone. This heat is used to fuse the metals to be joined and where additional metal is required, a filler rod may be fused into the work. The arc, constantly maintained but broadly adjustable in size and in intensity, lends itself to a wide range of work.

Magnetically-Controlled Arc Welding. It is claimed by one manufacturer that the superimposing of a strong magnetic field on the arc flame permits the arc to travel through variable magnetic fields without disturbance, and that welds made by this new process are more uniform in structure and ductility than those of ordinary arc welding.

Control

Generally, the evolution of dependable, definite timing devices has limited the use of current limit and counter e. m. f. schemes of control. The general run of magnetic control is now of the definite time accelerating type.

The year 1927 saw a great deal of development and improvement in thermal overload relays for motor protection and protection for other machinery. The developments during the year are also noteworthy with respect to improvements in magnetic switches. Much has been learned with respect to the characteristics of different metals used as contact breaking and carrying points, also with respect to the advantages of multiple break per pole.

Automatic Pump Control. The use of a sequence drum has made an improvement in automatic pump control. This sequence drum provides the automatic control to start the pump at high-water level, stop the pump at low-water level, and go through the priming process in starting. It repeats the priming cycle three times if necessary to prime the pump. The sequence drum is motor-operated.

High-Pressure Valves. In connection with the motor operation of large valves in steam power plants and in the chemical industry, the trend is toward extremely high pressures, up to 3000 lb. per sq. in., and relatively high temperatures. This has imposed unusual requirements as to the positive and accurate seating of the valves. The standard motor control, with a mechanical limit set for an accurate number of turns of the yoke nut, under certain conditions, would not close the valve tight, or, under other conditions, it might seat the valve before this mechanical limit was reached and thus damage the valve seat.

To meet these conditions, a torque-limit valve control has been developed. This control assures the seating of the valve at a definite predetermined seating pressure, or a fixed torque of the motor.

To obtain satisfactory results on high-speed presses driven by a-c. slip-ring motors, a special control equipment has been developed. A torque relay is used in connection with the equipment, which controls the torque of the press through a torque switch during the transition period. As the main motor accelerates, this torque relay controls the main motor and interrupts the acceleration when a certain speed and torque is reached. If, during the transition period, the speed falls below a certain point, this torque relay will again close the torque switch, tending to accelerate. The controller is operated from a push button station.

Paper Machine Drives. A control system has been developed for giving remote control of the paper speed on sectional paper drives.

The voltage regulator and the motor-operated rheostat is controlled by a push-button located at the machine floor and the speed changes are accomplished without the attendance of an operator at the switch control.

Furnace Top Control. A variable-cycle furnace top controller, for use in connection with the McKee revolving top, has been developed.

Holland Tunnel Supervisory Control. The control equipment for the ventilation and operation of the Holland Tunnel connecting New York City with New Jersey has been designed to be handled by one man. The supervisory operator knows and sees exactly how every piece of apparatus composing this gigantic network is performing. He can tell whether the incoming line breaker is still feeding the equipment, or whether it has tripped out automatically; whether or not the designated fans are running properly at the selected speed; whether the percentage of poisonous gas is dangerous in any section of the tunnel; if a fire alarm has been sent in, and what section is affected. The level of the water in the various sump chambers can also be determined by certain lamp indications. Should any change be made in the position of any particular apparatus, due to some fault or failure, a bell alarm will be sounded and a bright light will indicate the location and character of the trouble.

Miscellaneous Applications

Brick and Clay Industry. In one of the large Hudson River soft mud plants, a complete electrified installation is being built.

Ceramic Industry. Electrical energy is now recognized as an ideal fuel, particularly for ceramic manufacturers.

Textile Industry. Electric heating was adopted for the first time to the cloth singeing machines which are used in the finishing rooms of textile mills. The singeing was previously done by gas or oil heat.

Lighting. The application of an electric flashing system and a lantern of new design displaced kerosene buoy lights on the New York Barge Canal.

Artificial light has been further used in the horticultural field.

There has been a large increase in the application of lighting of special kind in the medical field where cures can be effected by the equivalent of sun rays.

Also in the medical field should be mentioned the application of cathode rays and their effects in the production of vitamines in yeast and other foods. This research has been aided by the development in 1927 of cathode ray tubes for operating potentials of 900,000 volts. In 1926 the maximum operating potential was 400,000 volts. The higher potential has increased the velocity and range of the cathode ray discharge.

Under lighting should be mentioned the enormous increase in applications of neon tubes for commercial advertising. Also the development of a new type quartz neon gas-filled lamp which resembles a ball of reddish orange fire and has great fog-penetrating possibilities.

A unique application of lighting is toward the elimination of certain moths and insects.

Individual Wire Blocks. The application of individual d-c. drive for wire blocks has rapidly increased. Between 350 and 400 blocks have now been installed in such a drive.

Tandem Drive for Strip Mill. Several continuous strip mills have been installed in the last year with individual motor drive in each of the mills where the material is in several mills at the same time but without any loops in the steel. This can be accomplished by d-c. motors.

Abridgment of

Sphere-Gap and Point-Gap Arc-Over Voltage
As Determined by Direct Measurement

BY JOSEPH S. CARROLL[1] and BRADLEY COZZENS[2]
Associate, A. I. E. E. Associate, A. I. E. E.

***Synopsis.**—This is a report of some of the work done at the Ryan High-Voltage Laboratory, Stanford University, during the school year of 1927-28. A new method of measuring high voltages, in which the current through a water resistor is recorded on an oscillograph, is described. Over a million volts to ground were measured with an accuracy believed to be better than 2 per cent.*

A calibration of the meter sphere-gap was determined for voltages up to 1100 kv. and the arc-over voltages for point-gaps were determined for distances up to 30 ft. Point-to-plane arc-over voltages also were measured.

Included in the report are some tests made in connection with the shielding of the water resistor determining to what extent capacity currents were causing error.

Sphere-gaps were used also in connection with the determination of the arc-over voltages of the point-gaps, to determine whether there was any high frequency set up by the heavy corona streamers from the point that could not be recorded by the oscillograph.

The procedure of taking an oscillogram of the corona current from a pointed electrode a million volts above ground is described.

The practicability of he use of the meter sphere-gap for voltage measurement is discussed.

* * * * *

Introduction

At the time of this investigation, the methods of direct-voltage measurement were limited to the sphere-gap, point-gap, dividing condenser as used with electrometer or cathode ray tube, and direct measurement of the current flow in a condenser of known capacity.[3] The calibration of the 100-cm. sphere-gap was for the most part theoretical, based on electrostatics and values determined on spheres of a lesser diameter.[4] The values of arc-over voltage for point-gap for voltages in excess of 900 kv. was a matter of extrapolation of sphere-gap comparison. It was known by those familiar with the use of these gaps that their action was not positively established. The object of this investigation was thus to establish the calibration for the meter sphere-gap and point-gap for the higher voltages, based upon values obtained by direct measurement within a limit of error of 2 per cent.

1. Assistant Professor of Electrical Engineering, Stanford University.

2. Research Engineer, Bureau of Power and Light, City of Los Angeles.

3. L. W. Chubb and C. Fortescue, *Calibration of the Sphere-Gap Voltmeter*, A. I. E. E. Trans., 1913, Vol. XXXII, p. 739.

4. F. W. Peek, "Dielectric Phenomena," McGraw-Hill Book Co.

Presented at the Pacific Coast Convention of the A. I. E. E., Denver, June 25-29, 1928. Complete copies upon request.

Method of Voltage Measurement

The method used here was the measurement of the current through a known resistance. The ordinary oscillograph was used as the current measuring device. This made possible not only the determination of the magnitude but also the wave form of the voltage. The 20-megohm resistor consisted of a glass tube, filled with distilled water. This tube was 16 ft. long and 0.4 in. inside diameter. The voltage was raised to arc-over in approximately one second by closing in the field switch of the generator. Due to the high specific heat of the water, the rise in temperature was not over 10 deg. cent. This caused a change in resistance of about 15 per cent.

Operations Necessary for Voltage Measurement. The procedure for the measurement of arc-over voltage may

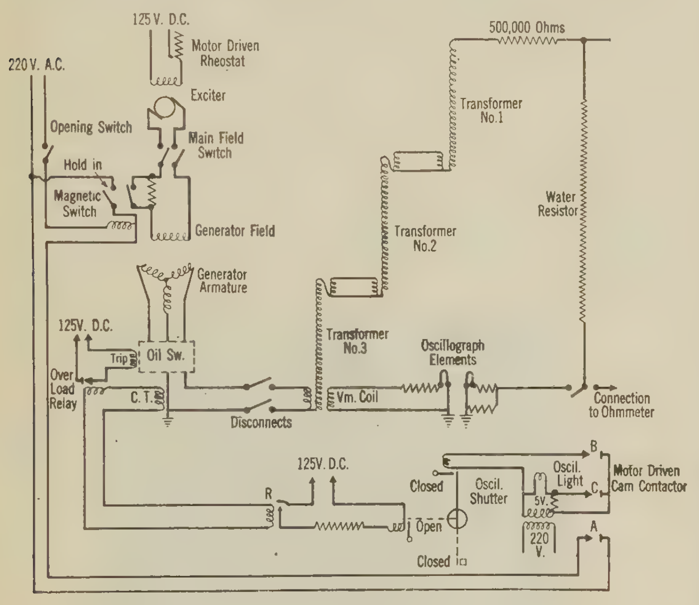

Fig. 1—Simplified Diagram of Main Circuit

be followed from Fig. 1. First the generator oil switch and main generator field switch are closed in. The cam-operated contactor then closes contact *A* closing the magnetic switch and short-circuiting out all of the external resistance in the generator field. The voltage of the set is thus built up with the increase in generator field current and after approximately one second, the oscillograph shutter is opened by the closing of contact *B*. Just before this takes place, however, the closing of contact *C* boosts the voltage on the incandescent light used in the oscillograph. The voltage of the generator exciter is set by trial so that arc-over occurs sometime within 10 cycles after the shutter is opened. A quick-acting relay *R* closes the shutter in less than two cycles after arc-over. The generator oil switch is opened in six cycles by the action of the overload relays.

Resistance Measurement. The resistance of the column can be determined by means of a galvanometer and a 1000-volt direct current within 20 seconds after arc-over. The slight radiation occurring in this time is negligible.

Method of Oscillograph Calibration. The oscillograph element is calibrated by recording on the same film on which the record is taken a current from the sine wave generator having approximately the same crest as the current through the water resistor. The effective value of this current is read on a milliammeter. Fig. 2 shows a half section of film. Each record contains two waves; one is the current through the water resistor and the other is the voltage as given by the voltmeter coil of the grounded transformer. The amplitude of the cycle preceding arc-over is the value used in the determination of the arc-over voltage. The ratio of the amplitude of the record to the amplitude of the calibrating wave multiplied by the effective value of the sine wave current used in calibration is the effective value of a sine wave current having the same crest as the current through the water resistor. This current value multipled by the resistance of the water resistor is the total effective (sine wave equivalent) voltage computed from crest values.

Tests and Determinations

During tests at the Ryan High-Voltage Laboratory, it had been observed that at the time of arc-over of a 20-ft. gap between points, the voltmeter coil in the ground unit of the chain-connected set of six transformers indicated an effective value of terminal voltage 33 per cent less than that which was expected for the gap breakdown, based upon the assumption of 10 kv. per inch. It has previously been assumed in the explanation

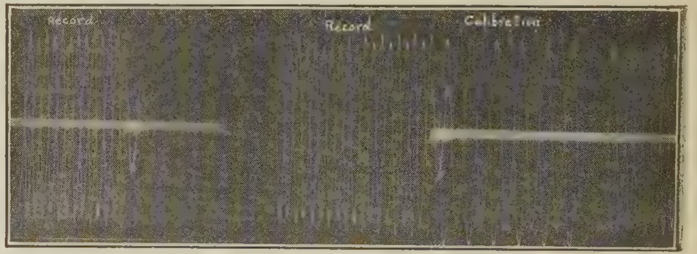

Fig. 2—Typical Oscillogram as Obtained for Voltage Determination

for the low voltmeter coil value for arc-over voltage that the heavy corona streamers accompanying the breakdown of the gap caused high frequency or surges to be superimposed on the 60-cycle voltage. However, the oscillograms showed that the arc-over of the 20-ft. gap was purely a 60-cycle breakdown, and that the crest value of the voltmeter coil value of terminal voltage was but slightly different from that as determined by the water resistor and oscillograph connected to the high-voltage terminal.

As may be seen from Fig. 3, the wave form of the voltmeter coil voltage is practically identical with that of the current through the water resistor, which is connected to the terminal of the transformer set.

Test for High Frequency. After some of the arc-over voltages had been determined by the above

methods, it was decided to use sphere-gaps as a check, lest there should be some high-frequency voltage that could not be recorded by the vibrator element of the oscillograph. The spheres available were two 100-cm. spheres and two 50-cm. spheres. Two gaps were made up, one for each side of the transformer set.

The 50-cm. spheres were mounted so that their

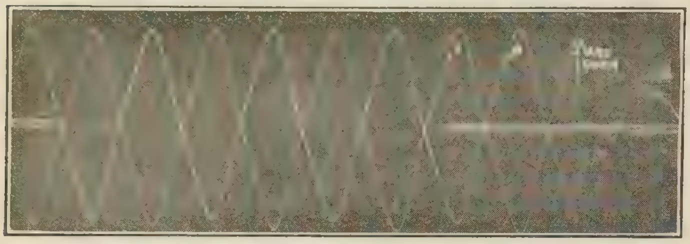

FIG. 3—OSCILLOGRAM SHOWING WAVE FORM OF TRANSFORMER SET AT 1,000,000 VOLTS TO GROUND

A—Current through water resistor connected to high-voltage terminal
B—Voltage wave from voltmeter coil of grounded transformer

centers were about 4 ft. from the concrete floor. Above these the 100-cm. spheres were suspended from the roof trusses by strings of 30 insulator units each (Fig. 4). This is not a standard sphere-gap set-up. However, the smallness of the lower sphere is partially offset by the proximity of the 50-cm. sphere to ground.

For each gap-setting, the spheres were adjusted so that the arc-overs were about equally divided between the point-gap and the sphere-gaps. The voltage was then determined by means of the water resistor and oscillograph. The following table shows the results for three gap-settings.

Separation of points	Separation of spheres	Point-gap (kv.-to-gd)	Arc-over voltage* Sphere-gap	Voltages for corresponding separation of 100-cm. spheres
16 ft.	70. cm.	854 kv.	861 kv.	880 kv.
20 ft.	83.5 cm.	942 kv.	945 kv.	946 kv.
22 ft.	102.5 cm.	982 kv.	988 kv.	1020 kv.

*Each voltage value is the average of three observations.

The results as given in the above table would indicate that the oscillograph was recording correctly the voltage that was impressed on the respective gaps.

When the two sets of sphere-gaps were being used with the 22-ft. point-gap, a very interesting thing was observed. During a preliminary test, one of the 50-cm. spheres and its mounting were removed, leaving an 8-ft. clearance from the 100-cm. sphere-to-ground. With the other sphere-gap set at 100 cm., the voltage was raised, and the 100-cm. sphere arced the 8 ft. to ground. This distance was more than twice that between the other spheres. The voltage was applied a number of times with the same result. The 50-cm. sphere that had been taken out was replaced and the gap adjusted for 110 cm. The voltage was then applied, and the 100-cm. gap arced over. This performance was repeated for the sphere-gap on the other side of the set with a similar result.

Shielding of the Water Resistor. The water resistor was partially shielded by a 3-ft. horizontal circular disk at the top. (See Fig. 4) For voltage measurements the shielding need not be nearly as perfect as for wattmeter work.[5] The effectiveness of the shielding was checked by taking simultaneous oscillograms at the top and at the bottom of the water resistor. The oscillograph at the top was a small two-element oscillograph, operated with a small motor. They were enclosed in a wire screen cage which shielded them from corona effects and external electrostatic fields. The oscillograph was operated by linen threads controlled by relays. The results of this test were as follows:

Record No.	Current at top of resistor	Current at bottom of resistor	Percentage of difference
1	52.7 milliamperes	51.7 milliamperes	1.9 per cent
2	49.1 milliamperes	48.2 milliamperes	1.8 per cent

Another test that was made on the shielding was in connection with the use of the sphere-gap of 100-cm. spheres. With the gap set at 100-cm., the arc-over voltage was measured with a water column resistance of 30 megohms and also with 10 megohms. Since there

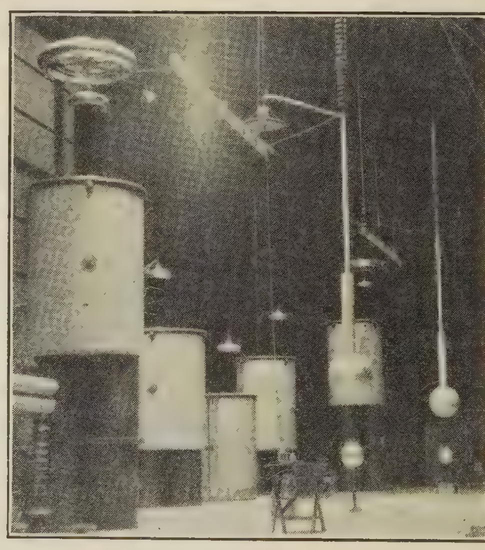

FIG. 4—SPHERE-GAPS AS USED TO CHECK POINT-GAP VOLTAGE

was nothing changed except the resistance of the water resistor, the capacitance current due to improper shielding remained practically constant. If this charging current were appreciable, the voltage as measured with the 10-megohm resistor would be noticeably different from that measured with the 30-megohm resistor. The average of 10 records in each case gave 994 kv. when the 30-megohm resistor was used and 1004 kv. when the 10-megohm resistor was used. Again

5. *Some Features and Improvements on the High-Voltage Wattmeter*, J. S. Carroll, A. I. E. E. TRANS., Vol. XLIV, 1925 p. 1010.

this shows that the resistor was shielded sufficiently for voltage measurements.

Discussion of Results

Point-Gap. Fig. 5 shows the arc-over voltage between two points for distances from 8 to 30 ft. for the neutral grounded condition. The height of the gap from the floor was approximately 30 ft. The plotted points are averages of from 5 to 20 observations.

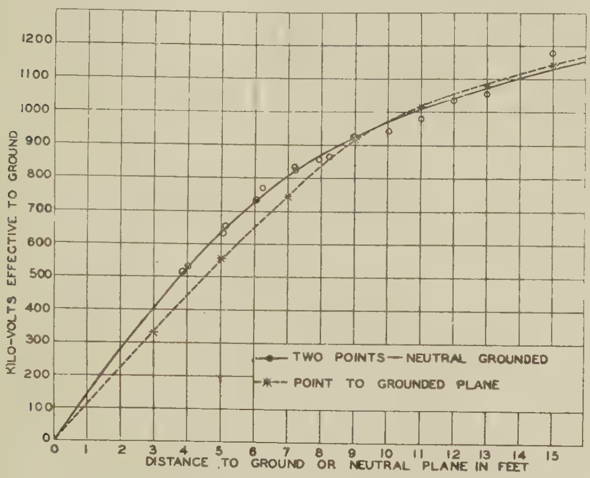

Fig. 5—Spark-Over Voltage for Point Gaps

Fig. 5 also shows arc-over voltages for a point-to-plane for distances up to 15 ft.

Fig. 6 shows the effect of ground on the arc-over voltage of a vertical point-gap 9 ft. in length, as the distance from the lower point-to-ground is changed. Each observation is plotted separately. The apparent dropping of the curve as the gap is raised from the ground plane in excess of 15 ft. is due to the lower or ground point nearing the high-voltage connections.

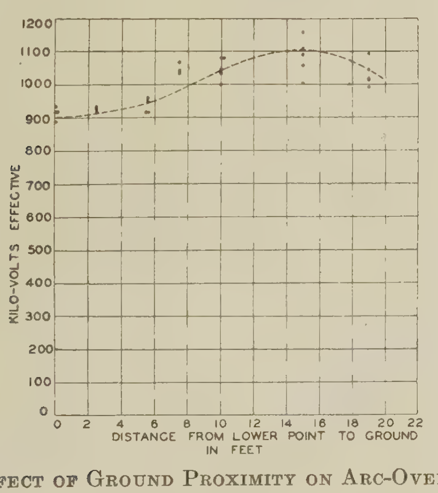

Fig. 6—Effect of Ground Proximity on Arc-Over of 9 Ft. Vertical Point-Gap

100-Cm. Spheres. Due to some inherent surface property which is as yet undetermined, the action of the 100-cm. aluminum spheres is rendered rather erratic where the separation between the spheres is in excess of 75 per cent of their diameter, and for smaller separations this erratic action may come in to a less degree. A typical set of readings is given in the following table for values of the Hendricks voltmeter coil voltage for 50 successive arc-overs of the 100-cm. spheres spaced 100 cm. These were the first values following cleaning and polishing of the spheres and are characteristic of many similar sets obtained during these tests.

Arc-over No.	Volt-meter reading	Arc-over No.	Volt-meter reading	Arc-over No.	Volt-meter reading
1	19	18		35	30.6
2	19	19		36	30.6
3	24	20		37	29.5
4	24	21		38	27
5	24	22		39	28
6	24.5	23		40	
7	24.5	24		41	
8	24.5	25		42	
9	26	26	30	43	
10	24	27	28	44	
11	26	28	27	45	29.5
12	25	29	30.6	46	30.7
13	26	30	29.6	47	30.8
14	26	31	30	48	31
15	24	32	29	49	31
16	27	33	31	50	31
17	27	34	30.6		

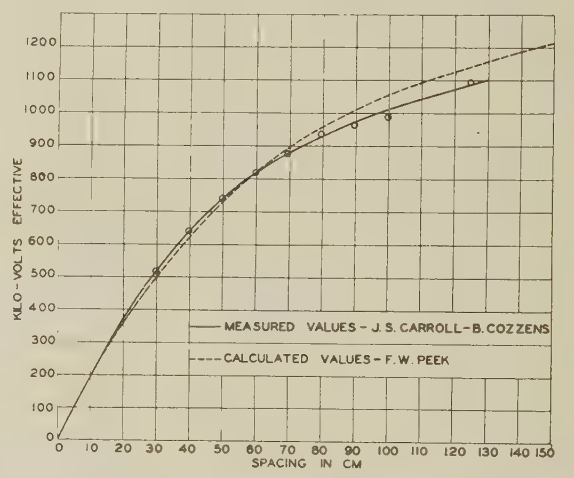

Fig. 7—Theoretical and Measured Values of Sphere-Gap Sparkover Voltage for 100-Cm. Spheres

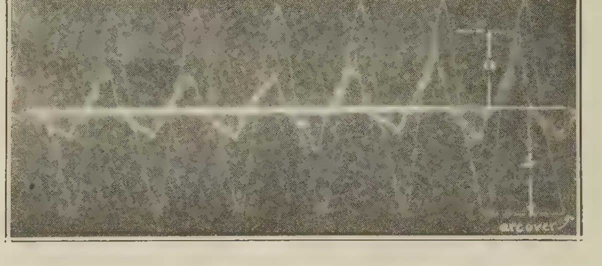

Fig. 8—Corona Current from a Point

The irregular wave is the oscillogram of the corona current, from a point 1,040,000 volts effective to ground

The crest value of the current at (*a*) is 28 milliamperes

The smooth wave is the current through the water resistor

The crest value of the voltage at (*b*) is 1,470,000 volts

From the above values it can readily be seen that at least 50 applications of voltage were necessary to get the spheres in condition, which fact in itself is no

small item when it comes to wear and tear on high-voltage transformer test sets. Such a conditioning was found to be necessary to a greater or less degree if the spheres remained unused for more than from 6 to 8 hours. This condition makes the voltage as determined by the sphere-gap somewhat uncertain unless particular precaution is taken to condition the spheres. It can be said that the arc-over voltage for a given sphere-gap setting will not exceed a definitive value, but the arc-over voltage may be as low as 50 per cent of this value.

The use of the sphere-gap for determining insulator flashover voltage has many disadvantages. A sphere-gap cannot be used to measure the exact voltage at which an insulator string will arc over.

Fig. 7 shows the calibration curve of the meter sphere-gap that was determined by the water-resistor-oscillographic method of voltage measurement. The values plotted are averages of the records taken. The maximum values obtained agree in all cases with the theoretical values of Mr. Peek. In all cases where records were taken the arc-over current of the gap was less than two amperes, and the duration of the arc was limited to six cycles. This value of current and duration of arc caused no noticeable pitting of the meter aluminum spheres. These spheres were arced over more than 1000 times during the tests reported in this paper.

Corona Current from a Point

The total current through the 500,000-ohm protective resistance was measured by means of a shielded two-element oscillograph and found to have a crest value of 154 milliamperes when the point was at a potential of 1,000,000 volts to ground.

While this set-up was in place, it was decided to obtain a record of the corona current from one of the points of the point-gap a few cycles before the arc-over of a 24-ft. gap. (See Fig. 8.) The lead from the oscillograph element was completely shielded up to the point. This arrangement eliminated all charging current and permitted the measurement of only the corona streamers from the point. The apparent difference in phase angle of this current and voltage wave is due, no doubt, to a space charge effect.

The oscillograph element was protected from the arc-over current by a low-voltage gap shunted across the element and the 10,000 ohms in series with it.

Abridgment of

High-Speed Circuit Breakers for Railway Electrification

From the Design Point of View

BY H. M. WILCOX[1]

Member, A. I. E. E.

FROM the switching service point of view, circuit breakers as a whole may be divided roughly into general classifications dependent upon the time required to isolate portions of the circuit under conditions of fault or to clear the circuit under any predetermined condition. Of these, the conventional normal-speed breaker constitutes by far the largest class in general use.

For d-c. switching service, this class is generally of the carbon-break type often applied in machine circuits with relatively high normal current loads requiring breakers of large current-carrying capacity with heavy moving elements. These breakers may be expected to interrupt a short circuit in from 0.07 to 0.10 sec. from the start of rise of short-circuit current although they are often used with a time-delay element intentionally placed in the control circuit to increase this time up to a full second or more. Where quicker action is desirable, particularly with breakers of lower current-carrying capacity, the contacts may be made trip-free from the closing mechanism and with a sensitive overload tripping device, the time may be reduced to from 0.04 to 0.06 sec. The general form of the breaker, however, is not materially different in these two time-classifications.

For a-c. switching service, the normal-speed oil circuit breaker is used over practically the entire range of service voltages. When actuated by a normal-speed relay, this breaker requires from 0.10 to 0.25 sec. after the occurrence of a fault to trip the breaker and interrupt the circuit. As in the case of the d-c. breaker, however, it is often used with a time-delay element in the control circuit, extending the total time up to as much as three or four seconds. Various forms of high-speed contacts are used for applications in which it is desired to reduce the period of arcing without necessarily diminishing the time between the occurrence of a fault and the final interruption of the circuit. Where

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this latter feature becomes desirable, high-speed relaying is resorted to with heavier accelerating springs in the breaker mechanism. In all of these forms, however, the breaker structures differ only in details and they may all be included in the same general classification.

During the last few years, the rapid advance in railway electrification work, particularly in the application of automatic features, has resulted in the development of a new class of breakers for this service known as high-speed circuit breakers. Developed largely for special protective purposes, these breakers perform a somewhat different function from that of breakers in other service for both of the two great classes of railway applications,—d-c. and a-c. electrification projects. In time classification, to interrupt a d-c. circuit, high-speed breakers should function in 0.02 seconds or less after the occurrence of a fault, and one cycle or less for a 25-cycle a-c. circuit.

In d-c. railway service, the synchronous converter operating at from 600 to 1500 volts occupied a commanding position as a medium for converting alternating current from the secondaries of transformers into direct current supplying feeder circuits for trolley or third rail service. This machine lends itself readily to automatic control without the necessity of an attendant, but it is susceptible to flashing with considerable consequent damage to the commutating apparatus under short-circuit conditions. To obviate this difficulty, the d-c. high-speed breaker has been developed to the point of interrupting a circuit before short-circuit current can rise to its full value, and of so limiting the destructive period of duration of a short circuit as to preclude the possibility of flashing on the commutator.

From the design point of view, to meet the requirements for high-speed protection in d-c. circuits certain characteristics must be incorporated in this breaker. The operating voltage for the majority of railway applications is 600, with a comparatively small number of 1500 volts, so that a single break of from 1¼ to 1½ in. will be sufficient for the contacts when used in conjunction with an auxiliary magnetic blowout circuit. With careful attention paid to design of the contacts in order to reduce the air-gap in the blowout magnet to a minimum, a blowout value of the order of 20,000 ampere-turns at 5000 amperes will be sufficient where high-speed interruption is confined to current values of from 3000 amperes upward. For small kilowatt capacity machines, where high-speed action is desired for currents as low as 800 to 1000 amperes, blowout values must be materially increased to assure satisfactory results in operation.

Blowout values of this order may be expected to remove an arc from the contact surfaces and transfer it to arcing horns during the first one-quarter inch of contact travel. Therefore all of the mechanical force applied to produce acceleration of the moving contact, on opening, should be concentrated so far as possible in this first one-quarter inch of travel, and no further importance need be attached to the speed of contact opening beyond this point except to insure that there is sufficient contact separation at the time the arc is extinguished to prevent reestablishment of the circuit. The problem then becomes one of acceleration rather than of high speed, since the accelerating force, while quite large, is not applied for a sufficient length of time to produce relatively high speeds.

From this it will be apparent that for d-c. service any feature which detracts from the amount of contact opening during the first 0.004 second after the breaker is tripped will hinder the limitation of current very materially. For instance, an auxiliary arcing contact with a quarter-inch lead would result in a complete loss of this time and a flexible brush contact involving a one-eighth-inch follow-up would result in a loss of nearly 70 per cent of it. Consequently, where feasible, a solid butt contact without auxiliary arcing tips becomes very desirable. Such a contact also permits working to a much higher current density, resulting in a very considerable reduction in the mass to be accelerated since there is no flexible laminated copper present to suffer possible deterioration under excess temperatures. Given a design in which the flexibility necessary to secure adequate contact pressure is supplied by a spring,—working through leverage if necessary,—the solid butt contact becomes entirely feasible for this application.

The resulting design is, then, a solid butt contact which carries main current, on which the arc is drawn as soon as mechanical separation of the contact surfaces is obtained, and from which the arc is transferred to arcing horns very early in the opening stroke by a powerful blowout magnet. These arcing horns are an integral part of the arc chute and care must be taken in the design to arrange them so as to secure the greatest possible increase in the length of arc in the shortest interval of time.

In view of the rigid requirements as to time for the operation of high-speed breakers in d-c. circuits, the delay involved in releasing a mechanical latch of the conventional type becomes a severe penalty when this device is used. An arrangement which has been found well adapted for retaining the d-c. high-speed breaker in its closed position comprises a stationary holding magnet and an armature linked to the operating levers, so arranged that upon the decay of holding flux due either to the interrupting of holding current or to demagnetization from some other source, the armature will release and permit the contacts to open under the influence of the opening springs. As the armature must be given a high rate of acceleration, its mass will be reduced as much as possible, resulting in its being worked well up toward the knee of the saturation curve.

This being a protective breaker, designed to limit the rise of short-circuit current in the shortest possible interval of time after the occurrence of a fault, some form of tripping other than simply the consequence

of amperes of over-load becomes essential. An overload device is inherently unable to determine whether or not a load is to become a hazard until it has already reached the hazardous point, and this in the case of a short circuit of fast-rising current is far too late to limit that rise satisfactorily. A discriminating device known as an inductive shunt, whose action is based on the rate of rise of current, is best adapted to the requirements. The main power circuit in the vicinity of the holding magnet is divided into two parallel paths, one of which passes through the air-gap of the holding magnet

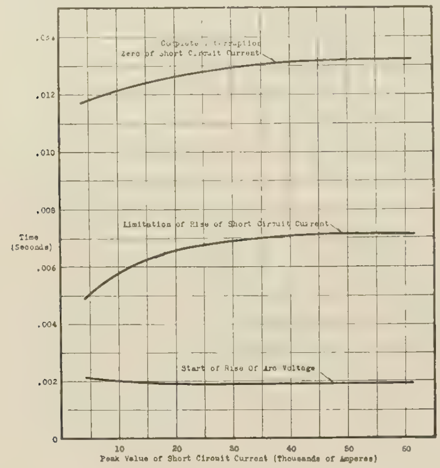

Fig. 4—Time Characteristics of High-Speed D-c. Circuit Breaker on Short-Circuit Test, at 600 Volts

while the second by-passes this magnet. Under conditions of steady load or of slowly-rising load, the by-pass lead carries a relatively large proportion of the current and the air-gap lead a small proportion which, due to the arrangement of potentials, produces a flux in the holding armature opposed to that generated by the holding coil current. So long as steady conditions or slowly-rising conditions obtain, the holding coil predominates and the armature holds the contacts in the closed position. The by-pass lead is, however, so arranged as to be acted upon by a laminated iron circuit which, in the event of a rapid rate of rise in current, acts to force a comparatively large proportion of the load through the air-gap lead momentarily. This results in a sudden increase in the demagnetizing flux in the holding armature which releases it and allows the contacts to open due to the action of the opening springs.

Fig. 4 shows the time characteristics of a high-speed d-c. circuit breaker over a considerable current range at 600 volts. For current rises of from five million amperes per second upward, for d-c. voltages up to 1500, these breakers may be expected to limit the rise of short-circuit current in from 0.006 to 0.008 sec. and to interrupt the circuit completely in from 0.012 to 0.016 sec. Tests on a 600-volt synchronous converter substation giving a current rise of the order of thirteen million amperes per second show limitation of short-circuit current across the busses to slightly less than 300 per cent of normal load. For machines whose characteristics give a slower rate of rise such as d-c. generators, the time of limitation and interruption of current will be proportionately longer while still providing adequate protection to the commutating apparatus. Fig. 5 is an oscillographic record of high-speed breaker performance on heavy current at 600 volts.

For a-c. railway service, the high-speed breaker assumes an entirely different form. The majority of such applications today are main-line electrification projects fed from overhead contact lines at 11,000 volts, 25 cycles, with frequent movements of heavy trains. On such applications, the use of high-speed breakers capable of limiting the duration of short-circuit current is of considerable advantage in lessening the shock to the system, in reducing the damage to contact lines and in minimizing the possibility of synchronous machines falling out of step. Furthermore, the use of high-speed breakers facilitates the coordination of propulsion and communication circuits when they are involved in an inductive exposure. As this propulsion service is almost entirely confined to a frequency of 25 cycles, one-cycle operation allows 0.04 sec. for the detection and interruption of a short circuit.

Essentially a single-pole oil circuit breaker of the conventional gravity-break type, this breaker differs from the normal-speed oil breaker in that it carries a high-speed shunt-tripping device, provision for a high acceleration of the moving contacts, an auxiliary mag-

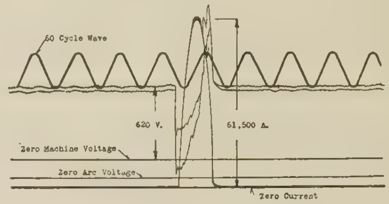

Fig. 5—Oscillogram Showing Performance of High-Speed D-c. Circuit Breaker on OCO Duty Cycle

netic blowout circuit for lengthening the arc rapidly, and is actuated by a specially-designed high-speed relay. Unlike the d-c. high-speed breaker, it carries no discriminating feature in itself but is actuated solely by the high-speed relay in which is incorporated all the characteristics necessary for such selectivity in tripping as may be desirable for any given application. The breaker carries a voltage rating of 15 kv. although all electrical clearances outside the interrupting chamber are adequate for 37-kv. service. It is designed for steady current loads of 1500 amperes at 25 cycles, and has an interrupting capacity of 50,000 amperes at 12 kv.

From the design point of view, this breaker presents a problem somewhat different from that involved in the d-c. high-speed breaker. The holding magnet raises problems due to directional characteristics when applied to a-c. circuits that require considerable in the way of added complications to overcome. Furthermore, this form of tripping does not carry inherently the degree of selectivity desirable for the majority of a-c. railway applications and some additional relaying becomes advisable when it is used. Consequently, a quick-acting mechanical latch released by a high-speed trip magnet, which, in turn, is actuated by a high-speed selective relay external to the breaker, becomes not only feasible but desirable from the point of view of close accurate settings for selective tripping.

The breaker must be trip-free in order to interrupt the circuit at high speed in the event of being closed against a fault. In the conventional form of oil circuit breaker, in order to combine the closing and tripping features in a single unit to insure simultaneous action in all phases of a multiple-pole breaker, the trip-free point is normally placed at the closing mechanism. Present-day a-c. railway applications in this country, however, are practically all on a single-phase basis so that a single-pole breaker meets all requirements. The trip-free point may then be placed as close to the moving contact element as mechanical and electrical requirements will permit, provided the tripping mechanism is placed at this point also. The point best suited to all these conditions will be found at the upper end of the contact lift rod, requiring only the contact, its lift rod, and one lever to be accelerated on opening. The accelerating force may be supplied by a helical spring concentric with the lift rod.

The design of the blowout magnet will vary somewhat depending upon the service in which the breaker may be applied. Where only low values of short-circuit current are to form a large proportion of the interrupting duty, a full iron return circuit may be used to work well below the saturation point. If heavy short circuits are anticipated, better results will be obtained with a magnet having a small section of return circuit designed to saturate at six to eight thousand amperes and forcing an air return path for the high current values. This is in order to eliminate the possibility of lengthening the arc unduly fast for very high current values having a heavy blowout force inherent in themselves. Care must also be taken in the design of this magnet from the viewpoint of temperature rise, bearing in mind that it must be excited by a series a-c. coil, and adequate means provided for radiation of heat. In this connection it may be noted that this application in railway service imposes a duty on trolley feeder breakers somewhat more severe than the standard N. E. M. A. duty cycle, in that they may be called upon to perform more than the stipulated two-O CO operations at full rated current, or a proportionately greater number at lesser current values, before an opportunity is afforded of renewing the oil. Provision should then be made in the design for a substantially larger amount of oil in the interrupting chamber than is required for conventional breakers of the same interrupting rating, and this increased body of oil will be of material benefit in taking care of heat radiation.

The design of mechanical latch for retaining the contacts in the closed position must receive careful attention in order to insure that the time of unlatching is reduced to a minimum. The conventional form of circuit-breaker latch, with right-angled holding face, involves inherent time delay, in that the holding face must be moved well over the center of the roller before the opening motion can start. With the heavy accelerating spring used, this form may also result in heavier loads than are desirable for high-speed tripping.

Fig. 12 shows the time characteristics of a high-speed a-c. circuit breaker on short-circuit test, including the operating time of the high-speed relay and shunt trip. This breaker is designed to interrupt short-circuit currents of from 2000 amperes, upward, in 0.04 sec. (one cycle on a 25-cycle wave) after the occurrence of a fault. For current values of from 15,000 amperes,

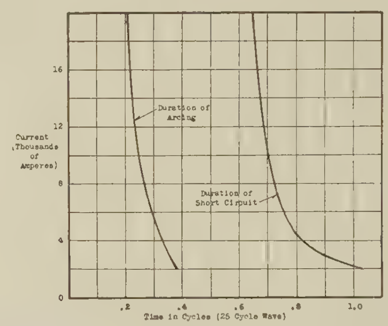

Fig. 12—Time Characteristics of High-Speed A-c. Circuit Breaker on Short-Circuit Test.

Including Time of Relay and Shunt Trip

upward, the breaker operates rather consistently in one-half cycle when the short circuit originates at or shortly after the zero point of the wave. In the event of the fault occurring relatively late in any given half-cycle, it will often persist through the next half-cycle before interruption. For current values of less than 2000 amperes, the time of interruption will still be of the order of one cycle, but due to the inherently low blow-out values involved, as well as the necessity of varied relay settings to secure selectivity, the short circuit may persist for an additional half-cycle. Tests made at current values of from 10,000 to 15,000 amperes over a voltage range of from 1500 to 12,000 volts show no appreciable difference in the duration of arcing, indicating that within the range of service voltage in present-day railway applications, the time of circuit

interruption for a breaker of this type is independent of initial circuit voltage. Fig. 13 is an oscillographic record of performance on short-circuit test at 11,000 volts.

A word as to the problems confronting the design engineer in attempting to apply high-speed breaker operation of this type to high a-c. voltage service or to multiple-phase circuits. It has been pointed out in this paper that an auxiliary blowout field is essential to high-speed interruption at the lower current values. Obviously, to be efficient, the blowout field must be so distributed as to supply not only an intense field at the point of origin of the arc but also a properly graduated field over the whole area in which the arc may exist at any stage of its interruption. As the service voltage increases, requiring the drawing of longer and longer arcs to rupture the circuit, these magnets must control ever-increasing areas, becoming in themselves more and more unwieldly to support in the breaker chamber with adequate insulation clearances. As the magnetic structure thus extends farther and farther downward into the clear break distance in the open position of the contacts in the effort to control the arcing area, to secure the necessary break distance for preventing re-establishment, the travel of the contacts must be increased by a safe amount, thus increasing the over-all height of the breaker structure and, incidentally, its cost. As we approach the point in service voltage at

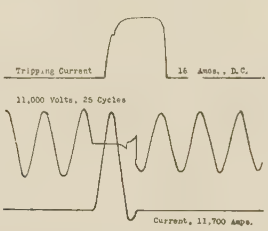

Fig. 13—Oscillogram Showing Performance of High-Speed A-c. Circuit Breaker on OCO Duty Cycle

which static shielding becomes necessary, these problems become so serious as to suggest seeking some method of securing the desired circuit conditions other than by the use of high-speed breakers.

As to application in multiple-phase circuits, it is obviously unsafe to permit the contacts of any single pole of a multiple-pole breaker to be operated independently of the other poles. This means that the tripping point must be so located as to control all of the linkage inside of all pole units as well as such linkage outside of these units as may be necessary to operate the several poles from a central point. This involves at once an increase of many times the mass to be accelerated at high speed and calls for a class of mechanical design not hitherto used to any extent in switching apparatus. At the best, there must be a very material increase in the power of accelerating springs used, and this power must again be reflected in increased closing loads, creating an additional problem not only of design but of application as well.

In general, the conclusion may be drawn that from the design point of view, adequate high-speed circuit breakers can be supplied to meet the present-day requirements for machine protection in d-c. railway circuits as well as such requirements as may be foreseen for some time to come. Also, adequate high-speed circuit breakers can be supplied to meet the requirements for protection for 25-cycle, single-phase, railway electrification work up to 12,000 volts. High-speed a-c. breakers for the next one or two steps above this in operating voltage for single-phase railway service seem within easy reach although not developed at the present time duty to an absence of demand for breakers at these voltages. A-c. breakers of this type for high-tension circuits, or for multiple-phase circuits at any voltage are not at the present time available, and seem to present problems requiring a substantial amount of development work before they may become available.

OUR DEBT TO MODERN LIGHTING

According to an editorial in the *New York Herald* the whole modern machine for disseminating information depends on night time reading; that is on cheap light. Without light, magazines would be impossible because no one would have time to read them. Books would be scarce, expensive and little read as, in fact, they were when light actually was poor and dear. Education formerly and otherwise; a good ¾ of prevalent human amusements; most of such activities as politics and social intercourse and culture of imagination would be impossible if light were costly and if man's day began and ended with the sun. Artificial light, the printing press and the idea that average minds are worth cultivating are three legs upon which rests for good or ill the fabric of the present age. Destroy any one of them and we return to dark ages in more senses than one.

Modern light, the editor continues, is a result of that second step of scientific research called development, a process in which many minds must share and which requires a continual stream of trained human material. If there were no cheap lamps for college students to work by there would be fewer trained engineers to help lamp development go forward and thus there would be fewer improved lamps and no improvement in college students and so around the circle again. Some day, lighting engineers tell us, we may look back on this age and call it dim, for it is claimed that ten or one hundred times more light than now might be used to benefit. But compared with Aristotle's day we are luminous indeed.—*Transactions I. E. S.*

Abridgment of

High-Voltage Gaseous-Conductor Lamps

Electrical Characteristics of the High-Voltage Neon Type

BY F. O. McMILLAN[1] and E. C. STARR[2]
Member, A. I. E. E. Non-member

Synopsis.—*Gaseous-conductor lamps are finding a wide field of application in advertising and display lighting.*

A brief discussion of the theory of the high-voltage type is included.

The electrical characteristics of typical high-voltage lamps were investigated by the use of indicating instruments, Duddell, and cathode ray oscillographs.

Characteristic curves, data and oscillograms are given.

Power-factor improvement was studied and data covering two methods of correction are included.

Introduction

THE field of application of the gaseous-conductor lamp is expanding very rapidly. In the form of neon signs, which are growing in popularity, it probably will include soon a large percentage of the total electrical sign load of the more progressive communities.

The investigation covered in this paper was undertaken in order to determine the various electrical characteristics of typical commercial neon sign lamps of the cold-electrode high-voltage a-c. type. Means of correcting the normally low lagging power factor were also investigated.

There are several other types of gaseous-conductor lamps including the low-voltage hot cathode type, the negative glow type, the electrodeless induction type, and the television type. These are not considered in this paper.

Theory of Gaseous-Conductor Lamps

The usual form of high-voltage gaseous-conductor lamp consists of a length of glass tubing containing gas at low pressure and equipped with sealed-in electrodes. The gas pressure is adjusted to a value that gives the lowest possible ionizing potential consistent with good tube life. Visible radiation accompanies the ionization by collision phenomena created when a sufficiently high potential difference is maintained between the two electrodes.

Various colors of light are obtained by the use of different gases and gas mixtures in conjunction with different colors of tubing. Twelve or more shades and colors have been obtained by this means.

A characteristic of all gaseous conductors is that the voltage drop between electrodes after the discharge has been initiated is practically independent of the current flow. Consequently it is necessary when supplying energy to lamps using gaseous conductors to provide a circuit having current limiting characteristics, because as soon as the discharge starts, the lamp gas becomes in effect a conductor, the resistance of which is an inverse function of the current.

Power Supply for Gaseous-Conductor Lamps

Because of its ease of voltage transformation and because any space charge effect within the tube is obliterated each succeeding half cycle, alternating-current provides the most convenient power source for gaseous-discharge lamps, particularly of the high-voltage type. Since the resistance characteristic of the tube is an inverse function of the current flow, the high-voltage transformer used to supply the tube is practically short-circuited as soon as the discharge starts. It is necessary, then, to employ a transformer of high impedance to limit the current flow. This impedance must be principally reactance, since if resistance were used, an excessive amount of power loss would be incurred.

When lighted to approximately the brilliancy employed in the usual neon sign, a 15-mm. neon tube about 11-ft. long requires an input of approximately 50 watts. This power is consumed very largely at the electrodes, (due to space charge effect and electron extraction from the electrodes). A tube of half the above length lighted to the same unit brilliancy would require much more than one-half of 50 watts.

Experimental Investigation

Electrical Characteristics. Several specimens of neon and neon-mercury tubing, such as used in commercial neon signs, and several neon transformers of the type commonly used for sign lighting, were obtained for test. The tubes were each 142 in. in length and 0.59 in. in diameter. The transformers were rated at 430 volt-amperes 110/12,000-14,000 volts.

For simplicity in designation throughout the tabulated data and on the curves, and hereafter in this paper, the neon gas filled lamps have been designated as "Neon" and the lamps filled with a mixture of neon,

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argon, and mercury have been designated as "Mercury."

The curves of Figs. 1 and 2 give the characteristics of series combinations of two neon tubes, two mercury tubes, and one neon and one mercury tube. Two sections of tubing involve the use of four electrodes in series and constitute an average practical condition.

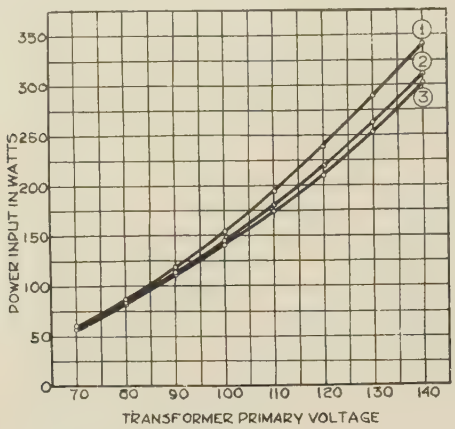


Fig. 1—Voltage-Power Characteristics for Two Tubes in Series

1. Two mercury tubes in series
2. One mercury and one neon tube in series
3. Two neon tubes in series

The power factor at normal voltage (110 volts primary) ranges from 35 per cent for the neon tube combination to 45 per cent for the mercury tube combination and is lagging. As explained before, the resistance characteristic of gaseous conductors is such that a transformer supplying a shunt load of such conductors must possess a high internal reactance in order to limit the load current. A transformer of this character, when virtually short-circuited, draws a current having a large lagging component which increases in magnitude as the resistance of the secondary load decreases. The effective resistance of the mercury tubes is made higher than that of the neon tubes in order to generate sufficient heat to vaporize the metallic mercury. Hence, it follows that a transformer loaded with these mercury tubes should consume more power at a higher power factor and lower current than when loaded with a similar number of neon tubes. The data and curves bear out this conclusion.

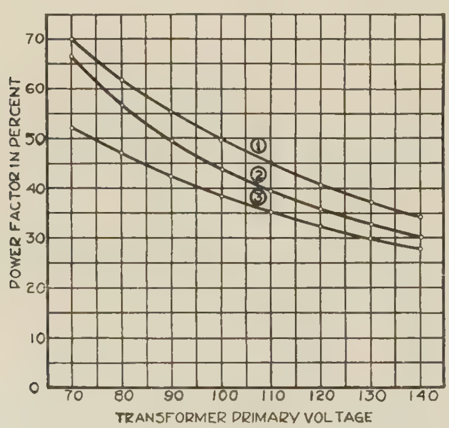


Fig. 2—Voltage-Power Factor Characteristics for Two Tubes in Series

1. Two mercury tubes in series
2. One mercury and one neon tube in series
3. Two neon tubes in series

The characteristics of series combinations of one, two, and three neon tubes are given in Fig. 3. Since the effective resistance of the transformer load depends upon the number of electrodes and length of tubing in series, it would be expected from the previous discussion that the power factor and power consumption would increase and the current decrease as the number of tubes in series is increased. The data and curves bear this out.

Oscillograms of voltage and current were taken on the

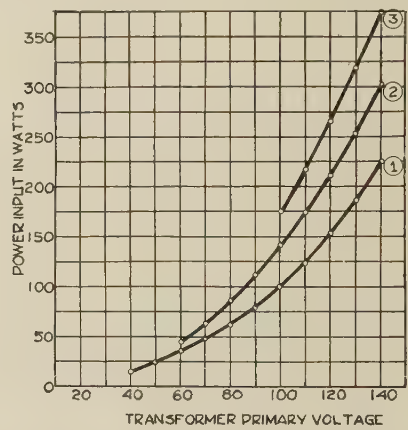


Fig. 3—Voltage-Power Characteristics for One, Two and Three Neon Tubes in Series

1. One neon tube
2. Two neon tubes in series
3. Three neon tubes in series

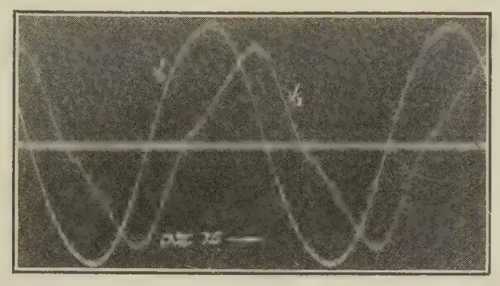
low-voltage and also on the high-voltage side of a loaded neon transformer. It was necessary to use a potential transformer to obtain the high-voltage wave forms. This potential transformer was a duplicate of the step-up transformer and had an appreciable effect upon the performance. However, cyclograms taken by means of the low-voltage cathode ray oscillograph which required no appreciable power (approximately 0.5 watts) showed the general characteristics to be unaffected.

The output voltage and current waves of a loaded transformer are shown in Fig. 5. In the upper oscillogram (OSC. 83), that taken with neon tubes, the very pronounced oscillation in the current wave is due to two factors. The initial part showing little decrement is produced by the impedance drop in the transformer drawing the terminal voltage down so low following each breakdown that the discharge stops only to be reestablished again as soon as the voltage recovers to the ionization potential. The latter part is the free oscillation of the circuit, that is between the capaci-

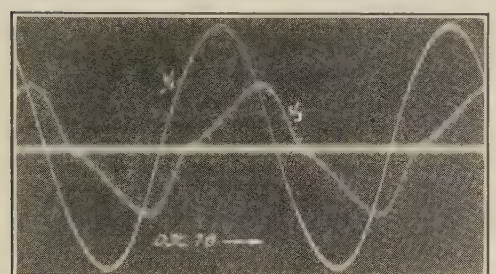
tance, inductance and resistance of the transformer and its load. This free oscillation takes place each half cycle after the high voltage has increased to a value high enough to sustain continuous ionization.

In the lower oscillogram of Fig. 5, (OSC. 86) that taken with mercury tubes, the current is lower, oscillations are much less pronounced and sustained voltage is higher than in the neon-tube case. All of these effects are produced by the increased resistance of the mercury tubes.

The voltage waves are interesting. In both oscillograms, at the start of each half cycle, the voltage rises from zero at a rapid rate following the normal open-circuit secondary sine wave until the ionizing potential is reached. At this voltage, sudden breakdown occurs, current begins to flow, and the circuit is set in oscillation. As previously explained, this oscillation continues without decrement until the voltage wave increases to a sufficient value to maintain continuous ionization, at which point, the free oscillation of the circuit begins and is damped out by the resistance of the tubes and transformer. Then, as the voltage attempts to rise still further, the ionization increases, a greater current flows, a greater transformer impedance drop results, and the terminal voltage remains practically constant until the normal voltage wave decreases to this constant value. At this instant, ionization ceases, the voltage passes on through zero, increases in the reverse direction until the ionization potential is again reached, and the above procedure is repeated.



Load—Three neon tubes in series



Load—Three mercury tubes in series

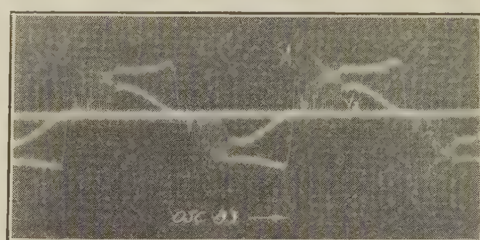
FIG. 4—LOW-VOLTAGE INPUT TO LOADED NEON TRANSFORMER

V_1 = Voltage 110 volts r. m. s.
V_3 = Current

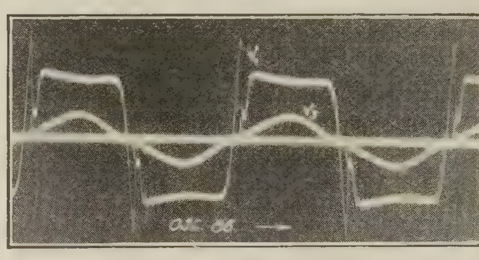
The performance of the tubes when carrying abnormally high currents was studied. Power was supplied by means of a distribution transformer rated at 15-kv-a., 11,500/115–230-volt, 2.4 per cent impedance. Power consumption values as great as 21.9 kw. were obtained with three neon tubes in series. Currents as great as 7.5 amperes (about 240 times normal) were passed through the tubes. The accompanying illumination was very intense and the tubes heated up rapidly. The oscillograph showed the same type of transformer output characteristics as those obtained with the small transformers (Fig. 5). The voltage drop across the tubes was obtained by potential transformer and voltmeter, and was found to be approximately 3000 volts for three neon tubes in series carrying 7.5 amperes. Under normal conditions of operation, with approximately 0.031 amperes in the tubes, the voltage drop as determined by sphere-gap and cathode ray oscillograph was substantially the same value.

POWER-FACTOR CORRECTION

The resistance characteristic of gaseous-conductor lamps makes it necessary that when operating on alternating current, they receive their power supply from a source of high impedance. This is accomplished most satisfactorily from the standpoint of power consumption and current requirement by employing high-voltage transformers having abnormally high leakage reactances. Such a load combination will necessarily draw lagging currents from the supply system.



Load—Two neon tubes in series



Load—Two mercury tubes in series

FIG. 5—HIGH-VOLTAGE INPUT TO NEON TUBES

V_1 = Voltage of two tubes
V_3 = Tube current

CORRECTION ON LOW-VOLTAGE SIDE OF TRANSFORMER BY USE OF STATIC CONDENSERS

By the use of static condensers shunted across the low-voltage side of the transformer, it is possible to correct the power factor to any desired value. In Table I is given the corrective volt-amperes and the corresponding condenser capacitance required to correct the power factors of the various combinations of tubes to 80, 90, and 100 per cent:

TABLE I
LOW-VOLTAGE POWER-FACTOR CORRECTION
110.0 Volts, 60 Cycles

Tubes		Power factor (lagging)		Low-voltage correction	
Type	Number in series	Uncorrected	Corrected	Volt-amperes (leading)	Condenser capacitance (microfarads)
Neon	1	0.234	0.800	419.	91.8
"	1	0.234	0.900	452.	99.0
"	1	0.234	1.000	511.	112.1
Mercury	1	0.264	0.800	390.	85.4
"	1	0.264	0.900	426.	93.3
"	1	0.264	1.000	491.	107.5
Neon	2	0.350	0.800	335.	73.3
"	2	0.350	0.900	382.	83.6
"	2	0.350	1.000	466.	102.0
Mercury	2	0.450	0.800	239.	52.3
"	2	0.450	0.900	291.	63.7
"	2	0.450	1.000	385.	84.3
1 – Hg + 1 – Ne	2	0.394	0.800	287.	62.8
" "	2	0.394	0.900	336.	73.5
" "	2	0.394	1.000	423.	92.6
Neon	3	0.461	0.800	255.	55.8
"	3	0.461	0.900	313.	68.5
"	3	0.461	1.000	418.	91.6
Mercury	3	0.621	0.800	74.	16.2
"	3	0.621	0.900	113.	24.7
"	3	0.621	1.000	182.	39.8

Correction on High-Voltage Side of Transformer

Interesting results can be obtained by employing a series condenser in the high-voltage circuit. Table II gives the results of a series of measurements using three neon tubes and various values of series capacitance. The power factor remains high over a wide range. Up to a certain point, the power requirement increases with increase in capacitance and then decreases. The tube brilliancy is in this case apparently roughly proportional to the power consumption. For very low values of series capacitance the tubes are unstable at normal voltage because through the resistance of the tubes the condensers charge up quickly during each half cycle and block off the current flow. As a result

TABLE II
LOW-VOLTAGE CONDITIONS AS AFFECTED BY HIGH-VOLTAGE SERIES CONDENSER
3 Neon Tubes in Series, 110 Volts, 60 Cycles

Low voltage			High-voltage series condenser (microfarads)
Amperes	Watts	Power factor	
1.87	204.	0.990	0.00715
2.21	241.	0.992	0.00813
2.99	329.	1.000	0.01080
3.48	383.	1.000	0.01250
5.29	578.	0.993	0.01730
8.34	862.	0.940	0.02210
10.10	740.	0.664	0.02470
6.76	384.	0.516	0.03260

the illumination persists for only a fraction of each half cycle.

Resonant conditions are produced by the series con-

TABLE III
POWER-FACTOR CORRECTION WITH HIGH-VOLTAGE SERIES CONDENSER
110.0 Volts, 60 Cycles

Tubes		High-voltage series condenser (microfarads)	Low voltage		
Type	Number in series		Current (amperes)	Power (watts)	Power factor
Neon	1	0.00553	1.22	113.	0.842 (Leading)
"	1	0.00652	1.53	138.	0.821 "
"	1	0.00776	1.82	164.	0.820 "
"	1	∞	4.78	123.	0.234 (Lagging)
Mercury	1	0.00553	1.30	126.	0.881 (Leading)
"	1	0.00652	1.56	148.	0.860 "
"	1	0.00776	1.97	183.	0.843 "
"	1	∞	4.62	134.	0.264 (Lagging)
Neon	2	0.00553	1.45	147.	0.924 (Leading)
"	2	0.00652	1.76	177.	0.912 "
"	2	0.00776	2.12	212.	0.910 "
"	2	∞	4.53	174.	0.350 (Lagging)
Mercury	2	0.00553	1.75	185.	0.958 (Leading)
"	2	0.00652	2.03	210.	0.942 "
"	2	0.00776	2.54	264.	0.943 "
"	2	∞	3.92	194.	0.450 (Lagging)
1 – Hg + 1 – Ne	2	0.00652	1.91	193.	0.920 (Leading)
1 – Hg + 1 – Ne	2	∞	4.18	181.	0.394 (Lagging)
Neon	3	0.00553	1.64	175.	0.972 (Leading)
"	3	0.00652	2.01	210.	0.950 "
"	3	0.00776	2.44	254.	0.948 "
"	3	∞	4.28	217.	0.461 (Lagging)
Mercury	3	0.00553	2.04	220.	0.982 (Leading)
"	3	0.00652	2.46	264.	0.977 "
"	3	0.00776	2.99	321.	0.976 "
"	3	∞	2.11	144.	0.621 (Lagging)

densers, and consequently voltages of abnormal magnitude appear across the high-voltage winding of the transformer and across the condenser.

If the series condenser correction were to be employed in practise, it would be necessary to insulate the transformers for approximately twice the high-voltage potentials that at present prevail.

Conclusions

1. The inherent characteristics of gaseous-conductor lamps are such that when supplied from an a-c. source, the transformer must have a high leakage reactance.

2. Because of the combined characteristics of the lamps and supply transformers, the currents drawn have a large lagging component.

3. Power factor is improved by increasing the number of tubes in series or by increasing their resistance.

4. The probable future almost universal use of gaseous-conductor sign lamps will necessitate the use of power-factor correction or the application of special power rates if the use of the high-voltage type lamp is continued.

5. Power-factor correction can be accomplished by the use of parallel capacitance on the low-voltage side of the transformer, or series capacitance in the high-voltage circuit.

Abridgment of

The Automatic Substation and its Relation to the Electric Distribution System

BY S. J. LISBERGER[1]
Member, A. I. E. E.

Introduction

SOME 15 years ago in a substation supplying power to an interurban electric railway system it was demonstrated that electro-mechanical devices could be made to operate the apparatus so successfully that human attendance might not be necessary. Since that time, the development of these automatic devices has been extremely rapid and as a result of the progress in this branch of the art, the automatic substation of today has reached a high state of development.

It must be borne in mind that the substation is a definite part of the electric distribution system and that the location of the substation in the distribution network has a most important bearing on the cost of the distribution system.

It is the desire of the author to point out some of the advantages to be gained by the use of the automatic substation and to discuss, in a general way, some of the factors which play a most important part in the distribution of the electrical energy to a community.

The automatic substation has been found ideally adapted to the following types of installation.

1. A supply of d-c. energy to urban, metropolitan, and interurban street railway systems.

2. The rural substation supplying only alternating current.

3. On consumer's premises where a special substation is necessary and where the customer's requirements may call for either or both alternating or direct current.

4. In supplying energy to a 220-volt d-c. Edison network in a metropolitan community of not excessive size.

5. In metropolitan areas where one or more types of service may be supplied from the same substation. The latter may involve a combination of several of the above types. There are, perhaps, several other classes that might be added, such as automatic operation of synchronous condensers at isolated points and a semi-automatic installation in a large station. This condition assumes that the station has a large number of units and that switching conditions require an attendant. In such a station, it is probable that complete automatic operation is not advisable, yet partial automatic operation may reduce operating expense and give better service than a completely manually-operated station.

It is today generally recognized that for certain installations the automatic equipment can be made more foolproof than manually-operated, and that in certain types of installations, the automatic equipment will restore service faster than the attended equipment.

Assume a medium size system, wherein one or more automatic stations are equipped with supervisory control, the control point being an adjacent substation. If such a system is to be operated on the orders of a central load dispatcher, and if the control station must obtain orders from the dispatcher before carrying out any switching operations in the automatic substation, it is probable that better service will develop if the automatic substation be of the fully automatic type rather than supervisory, as in times of trouble or if faults develop, the fully automatic substation will eliminate the defective equipment and will restore service faster than if supervised. However, there is always a feeling on the part of the operating man, in which he may be justified, that some one should know what is going on in the automatic substation, as apparatus may lock out and nothing will be known of it until the customer complains or the routine inspection takes place. Such operation may cause a serious impairment in the service. Hence, a combination of automatic and indication at some distant point may be found to be the ideal solution, as the equipment will take care of itself during times of trouble on the system or locally and at the same time some one knows whether the station is functioning satisfactorily or not.

Supply of Power to Urban and Interurban Railway Systems

In installations of this type, the automatic substation finds its ideal application. Certainly in both metropolitan and interurban communities, there is a large reduction in the amount of feeder copper necessary, with an attendant improvement in voltage regulation if the substations can be economically spaced and located.

If more than two machines are necessary, it is possible that some form of supervisory control equipment may be simpler and less costly in both installation and operation. This statement is particularly true if remote control indication is desired, since the control or indicating circuit would be existant and the addition of supervisory control would not be a costly addition. The installed cost of the automatic equipment for a railway machine, with feeders, represents an expenditure of approximately 30 per cent of the cost of the machine itself and the cost of this equipment does not

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materially change with the size of the machine, if units between 500- and 2000-kv-a. are considered. It is therefore desirable to use as large equipments as are economically possible, to reduce the number of units, the size of the building, and the number of switching elements, etc., and in order to obtain simpler operation.

Rural Substations, Isolated Consumers, and Special Synchronous Condenser Installations

The introduction of automatic devices has materially bettered the service, with only a slight increase in cost. The outages due to line troubles have been materially decreased by the automatic reclosing breaker, as trouble often clears on the first opening and service is resumed as soon as the breaker is reclosed.

To both the isolated consumer and rural substation, it is possible to give a most reliable type of service if two supply lines feed the substation, as the present-day automatic devices effect a quick transfer of the load from one circuit to the other in the event of interruption and will transfer the load back to the preferred circuit if desired.

The application of the automatic principle to the isolated synchronous condenser station for power-factor and voltage correction has made such installations economically justifiable since the substation does not require any attendant or housing facilities for him.

With most satisfactory performance of the automatic substation, it is now possible to locate such facilities at the most advantageous point on the distribution system. This means a reduction in the length of feeders, better regulation, and, particularly in rural communities, cuts down the length of individual feeders that in the event of line trouble, a large territory is not out of service at one time. Such rural substations occupy a small amount of ground space, and the apparatus can be housed either in steel cells or be made completely outdoor.

Supply of Energy to a 220-Volt D-C. Edison Network

Why should an existing d-c. supply be abandoned in favor of an a-c. supply?

If there are no batteries, or if the batteries are not sufficiently large to carry the system even at reduced voltage during times of system trouble, there is always the difficulty as to how service could be restored on the Edison network during times of system trouble. Such a d-c. network requires a large amount of copper and a large number of ducts. The capital investment and the operating expense for such a system, particularly if batteries are required, are greater than for an a-c. system of equal capacity.

With these general factors in mind, it is not difficult to see why the a-c. system is to be preferred. Yet, on the other hand, there is nothing simpler to operate than a d-c. Edison network, and maintenance costs for the underground system are not high. If a new system were to be built today, it is doubtful if the d-c. would be installed; and yet where such systems are installed, with the changed conditions brought about by the automatic substation, it is likewise doubtful if an a-c. supply should be selected to supplant the existing d-c. system. With the newer types of motor-generators with load limiting and similar characteristics, and with the automatic devices now available, if the d-c. system can be fed from a number of substations with not more than two units per substation, a very economical and high quality of service can be rendered. The d-c. system can be operated as a network with a material reduction in the length of feeders, number of ducts, and consequent savings in losses and investment, and without storage batteries,—the automatic equipment restoring service most satisfactorily in the event of trouble. It is not intended to imply that automatic equipment in a system of this type is the equal of manual stations with storage batteries, nor that in extremely large metropolitan areas where the density of load is very heavy, the automatic substation can supplant the manual substation entirely. The distances between substations will not be great and as there will be rotating apparatus installed, and as the service demanded must be of an excellent character, it is probable that some form of supervisory control will be most advisable. An a-c. supply to deliver service equal to that of direct current should be operated as a network. Such a supply means large transformer vaults, with some problems of ventilation, network protectors, etc. Certain existing consumers will still demand some d-c. supply, for which there must be some form of conversion apparatus.

Owing to crowded street conditions, it is not always possible, to find ample space for the necessary a-c. facilities.

Automatic Substations in Metropolitan Areas

In large metropolitan areas, the use of the automatic substation vs. the attended station requires more careful consideration than in any other situation, as there are many things that affect the problem, such as the several classes of service that may have to be supplied out of one station, the density of load, the cost of the supply lines to the substation, the cost of real estate and building, and the question of fire risk.

If the utility is to supply several classes of service,—such as a street railway system, d-c. Edison service, a-c. service for industrial purposes, and street lighting, all out of the same station,—it is most probable that the variety of service and amount of apparatus can best be served from an attended substation. With such an installation, the application of partially automatic operation, such as reclosing feeders on the a-c. system, automatic operation of all station auxiliaries, automatic starting of railway motor-generators or rotaries, will be justified, as it will reduce the number of attendants and at the same time better the service.

Where the generating capacity is of such an order that the use of oil switches of high rupturing capacity is

necessary, switching costs at the substation are factors in the cost of the total development. In order to reduce the cost per kv-a. of switching and underground lines, supply cables must be of such a size that they will carry loads of approximately 7000 kv-a., (assuming the supply system is 12,000 volts) and to further reduce costs, it is possible to eliminate the switching at the substation end by treating the cable and transformer bank at the substation as a unit, thus saving not only the cost of switches, switchboard, etc., but the building space also.

The automatic station lends itself particularly well to this design if a spare cable and transformer bank unit are installed,—the banks feeding the secondary bus through oil switches, the secondary bus, in turn, being arranged in units with a given number of feeders per bank, and the secondary bus sections so arranged that they can be tied together through oil switches. In the event of a failure of a cable or bank unit, the main secondary oil switches on the bank open, the secondary bus tie switches close, and the other bank takes the load. Such an installation can be made with two or more banks and cable units, it being necessary that the bank and cable unit have some spare capacity in order to take the load of the adjoining section.

Such an installation requires no switches on the high-voltage side, a minimum number of relays, is without the complications of high-tension switching, and it is would probably be cheaper than any other installation, if the costs of switching and building are of serious moment in another type of design.

Remote Load Indication and Other Metering Equipments

If the distribution network is fed by a number of substations and if the feeders are, or can be-tied together through sectionalizing switches, it is often desirable to know the load the several units in the automatic substations are carrying; this is all the more important if the station is of supervisory control, as the control station must be in a position to know when to put in and take out the supply units.

Substation Design

The design of the automatic substation is somewhat different from the attended substation. The most important elements to be noted are:

1. The design of the building if apparatus must be housed, or design of the structures if it is to be outdoor.
2. Ventilation in the case of housed equipment.
3. Fire risk.
4. Economical arrangement of apparatus, particularly with relation to the building structure, and with the interconnected devices.
5. Arrangement and grouping of the apparatus to facilitate quick inspection, and location of faults.

Building Design. If the substation is to be located in a residential area, special treatment must be accorded the building to make it harmonize with the surrounding property. It must be architecturally attractive, very probably should not be over two stories high, and must be of such construction that if the apparatus located therein is noisy, such noise will be confined to the building.

In a noiseproof station, it will be necessary to provide some form of double walls; that is, an outside wall with intervening air space between it and the inside wall, the latter being of plaster or similar material. In place of the double wall, it is possible to use sound absorbing materials. It will be found advisable to eliminate all windows and skylights and reduce the number of doors to a minimum, using a heavy door of wood construction and then placing a removable covering over this door, such covering to be placed on the inside of the station, and built of soundproof materials. It must also be bolted tightly against the main door frame. The smaller entrance should be through a vestibule having two doors. All cracks around the doors must be absolutely tight, as small cracks offer a passageway for a large amount of sound.

The air entrances and exits must be properly baffled. It is probable that in a residential area, all wires leading to and from the station will have to be underground for at least a limited distance. If the station contains several classes of apparatus located in separate rooms, it may be necessary to build only one part noiseproof, the static apparatus not causing sufficient noise to require the extra precaution and expense necessary with rotating machinery.

A very economical design has been worked out, wherein all wires are brought to the substation underground, such wires terminating in a steel cell which houses the oil switch, instrument transformers, disconnecting switches, switchboard instruments, etc. Bypass switches (air type) are provided in the cell to allow for inspection of the oil switch. All leads to the transformers and regulators are wiped in. This type of design has a decided advantage, in that there is not an exposed wire in the installation. Indoor equipment (which is cheaper than outdoor and incidentally more easily obtained) can be used. (For complete details, see article by R. C. Powell, *Electrical World,* Feb. 26, 1927, Vol. 89, p. 449.)

Ventilation. If ventilation is required, it presents no difficult problem; it is only an added expense. In order to reduce the quantity of dust and dirt brought into the station, it will be found advisable to install a dry filter type of air-cleaning equipment. The installation will be found justified by the reduced cleaning and maintenance that would otherwise be necessary.

These filters will not decrease the passage of noise, and if noise is to be eliminated it will be necessary to provide baffles or mufflers both in entering and leaving air passages. The ventilating installation may require either forced or exhaust fans, or both. If the substation is under supervisory control, and if the load has a definite daily characteristic, after the temperature

characteristics of the station are known, the fans can be controlled from the supervising station. The use of thermostats for starting and stopping fans is quite reliable and low in first cost.

Fire Risk. The building should be of fireproof type. The question of fire risk has received, perhaps, the least attention, and yet it is one of the most important of considerations. While electric fires are few in number, they do occur, and if in an unattended station, considerable damage may result before anything is known of the accident.

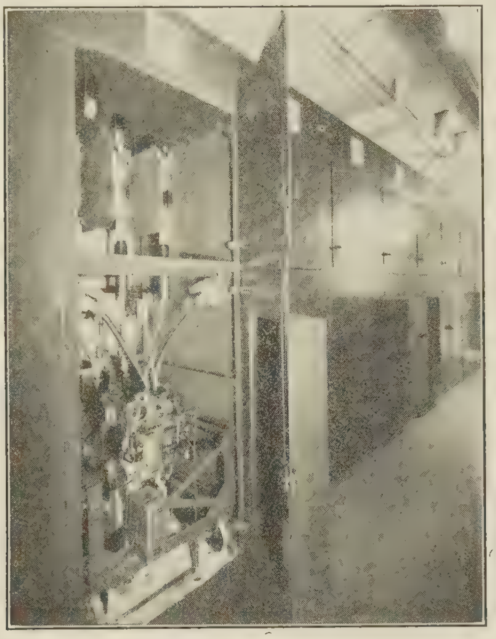

FIG. 1—11-KV. SWITCHES IN STEEL COMPARTMENTS

A simple roll-out type of switch is used requiring less space than the truck type. Control connections are made through flexible couplings

It is therefore most desirable to locate transformers out of doors, or to house them in a separate building or part of the substation. It is entirely probable that they can be located outdoors in such a way as not to be unsightly, particularly if they are protected by a wall or screen. It is advisable to have all connecting leads wiped in rather than have exposed bushings.

Oil switches should be in compartments with barriers so arranged as to prevent the spread of fire and the flow of oil in the event a tank bursts, (Fig. 1). Induction regulators cases should be of strong construction, preferably boiler plate type; there should be proper barriers between each group, a small pit or oil dam being provided for each set. If there are high-tension switches, it will be advisable to locate them in a part of the building isolated from the other apparatus, and should there be any large number of switches or regulators, it may be advisable to erect partitions which will provide a number of small rooms instead of one large open space. The location of the apparatus with reference to adjoining apparatus, wiring on the switchboard, etc., should receive most careful consideration.

If a fire should occur, it is necessary to have the ventilating fans stop. This can be done by locating fusible links at critical parts of the room the links so arranged that they will open the control circuit of the ventilating fan; if the substation is of supervisory or indicating type, the opening of such circuits could be registered at the control point.

Arrangement of Apparatus with Relation to the Building Structure, and Grouping to Facilitate Quick Inspection. The designer of the station must consider both of the above features when laying out the station, as it is essential that an economical arrangement be had, and at the same time it is equally essential that the apparatus be so grouped that trouble may readily be located if and when it develops.

It may be found advisable to arrange the switchboard in two sections, (back to back), the machine relays and instrument equipment; the feeder equipment, such as the relays and circuit interrupters, being on the front board, and on the board to the rear, the disconnecting switches and such relay and metering equipment as is not essential on the front board, (Fig. 2). This arrangement has decided advantages. It makes possible reduction in the length of the building; but more important, it permits the placing of the heavy bus in a position well above the other apparatus, thus making it easy to connect the bus to the breakers, or circuit interrupters, and the disconnecting switches. At the same time leaving the backs of the boards clear of heavy copper, which, under the older type of installation, makes it extremely difficult to get at or change incidental wiring on the rear of the panels, (Fig. 3).

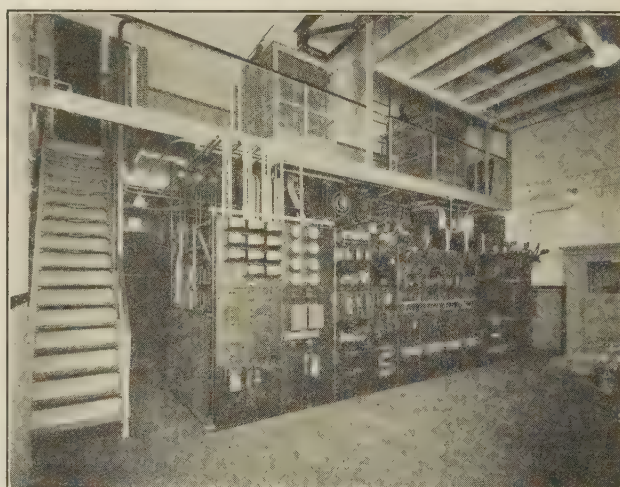

FIG. 2—FRONT OF SWITCHBOARD

Contains 11-kv. control panels, automatic equipment for two machine control, and four feeder circuit breakers. Note the load-limiting resistors on the gallery

Where fuses are used on 600-volt potential or control circuits, the cartridge should be enclosed in a non-

conducting, fire resisting box, as the failure of a fuse to function properly is likely to cause serious destruction to the adjacent wires.

Where rotary converters are used, the placing of the transformers outside of the main building has distinct advantages in reducing the cost of the building and ventilation. They should be located as close to the machines as possible to reduce the length of the secondary leads. When on the negative side of the machine, the high-speed circuit breakers should be as close to the machine as possible and adjacent to their complementary resistors. The machine and breakers can be treated as a unit, as this equipment must be out of service if it is desired to work on any part of the unit. If these devices are not located close to the machine, long runs of heavy cable and control leads are necessary. An example of how this apparatus may be grouped and made a part of the unit is shown in Fig. 4.

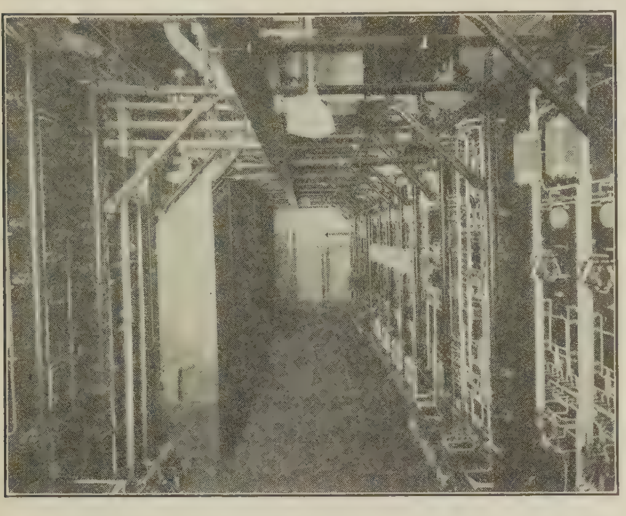

FIG. 3—VIEW BETWEEN FRONT AND REAR SWITCHBOARDS

Note the absence of heavy copper runs on back of panels. Metal trough overhead is divided into three compartments with removable sections on sides. Note ease with which the interconnecting leads are taken out of this box to various control panels. Barriers on left are between the d-c. feeder panels

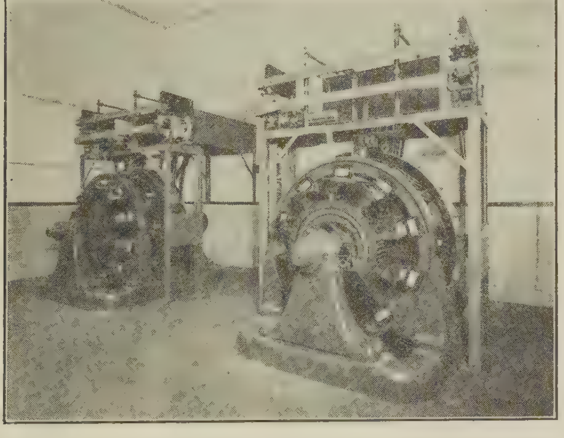

FIG. 4—TWO 1500-KW. 600-VOLT CONVERTERS

Note short leads from the machine to the two high-speed circuit breakers on negative side. The metal boxes overhead enclose the secondary leads from transformer

CONCLUSION

The automatic substation has been developed to a high degree of perfection. It can be relied upon to deliver an excellent type of service, particularly if proper precautions are taken in design and installation. In many cases it will deliver better service than that given from an attended station. Careful inspection and maintenance will prevent much trouble.

This development has provided means for locating the supply station at those points in the distribution network where previously such a station would not have been economical, and as a result, large economies in the distribution network can often be effected by the application of the automatic substation; but to make this possible, it is essential that the substation investment should not overbalance the saving to be effected in the distribution system.

USE OF MEGGER CIRCUITS IN GEOPHYSICAL PROSPECTING

The increasing interest in the use of electrical or other geophysical methods for the location of underground ore deposits has led the United States Bureau of Mines, Department of Commerce, to study the possibilities of the use of the megger circuit for the measurement of the variation of ground resistivity, an important factor in this means of mineral prospecting.

The megger may be used to measure the various average resistivities at different depths from the surface or to compare the various average resistivities at the same depths. With its use it is possible to locate the direction of the dip and strike of a concealed instrusion, such as a body of ore. About three sites or areas can be measured in one day to a depth of 600 ft. by a crew of three men.

The megger as it is built at present is not entirely suited for geophysical prospecting, states Doctor F. W. Lee in Technical Paper 440 recently issued by the Bureau of Mines. Various improvements which would help in the operation of this instrument in the locating of underground ore bodies are summarized in Technical Paper 440, copies of which may be obtained at a price of 10 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Ottumwa, Iowa, is seeking a permit to allow the city to straighten the channel of the Des Moines River in its flow through the city, this movement being in the cause of flood protection. Horace A. Brown, superintendent of the Ottumwa waterworks, has a plan involving the installation of a hydroelectric plant, by which means, it is held the cost of the project, approximately $1,000,000, could be reimbursed.

Abridgment of

Automatic Stations

ANNUAL REPORT OF COMMITTEE ON AUTOMATIC STATIONS

To the Board of Directors:

The Committee on Automatic Stations was appointed April 8, 1927. This, its first annual report, will give a general description of automatic station development during the past decade, and will enlarge upon some of the more important new features brought forward during the past year. Research, operation, standards, bibliography, and suggestions for future study will each receive attention.

Research

Research has been carried forward by operating and manufacturing companies with assistance rendered by several universities. The principal studies have been concerned with the operating requirements of devices for various classes of service. The number of cycles of operation per year for some of the more important devices have been determined.

Overcurrent relays, differential relays, and other similar protective relays, operate through about 300 or less cycles per year. Overcurrent circuit breakers in railway service may operate through as many as 1000 cycles per year. Load-limiting resistors may be introduced into circuits by the operation of their short-circuiting devices from 500 times per year in Edison Service to 100,000 or more times per year in interurban railway service. Regulating relays may be called upon to operate between 1,000,000 and 30,000,000 cycles per year. Other devices may be called upon to operate between the limits as given for overcurrent relays as an average minimum and regulating relays as an average maximum. In order to derive a maximum benefit from the particular device in its particular service, each application, particularly to automatic station service, requires a full knowledge of operating requirements.

Another field of research has been in the determination of the minimum protection required for various classes of power apparatus in automatic stations. The results of these studies are given in the Standards for Automatic Stations recently approved by the Board of Directors. Still another field for research has been in the study of operating conditions and requirements so that the automatic stations might be designed along simpler lines to give greater reliability and continuity of service. Valuable assistance has bee nrendered to the manufacturers by the engineers of operating companies. Several papers were prepared and presented by these engineers describing their experiences with automatic stations. This has stimulated the manufacturers toward the development of less complicated devices which give more reliable operation and permit better service to be rendered by public utilities.

Development

Development has been directed toward simplifying operating sequence, reducing the number of devices required for various classes of equipment, and making the operation more positive and reliable. Controls have been developed recently for power rectifiers. A brief description of the outstanding features of these designs is given later.

Supervisory systems for the control of remote power apparatus have reached a high state of development. Several papers indicating the trend of this development have been presented to the Institute. Many refinements have been incorporated, and these systems are now considered to have an important field of application.

Telemetering is new. Only about a dozen systems including it are in service. Operating experience is needed. The state of development has not yet been passed. Several systems now being offered are simpler and more reliable than the older ones. They indicate that this important adjunct for automatic stations may soon be incorporated in standard designs.

Power Rectifiers

Power rectifiers are the latest type of power conversion apparatus to be used in automatic stations. These differ from the usual rotating power apparatus in that they have no inherent mechanical moving parts. They differ from the usual static power apparatus in that they require auxiliary features which have mechanical moving parts.

The power rectifier employing mercury is a static converter with a moving arc stream. The load responsive starting and stopping features of the control resemble those used for rotating synchronous converters. The methods used for starting and for stopping, and the protective measures resemble those used with static transformers having artificial cooling. Several features, however, are peculiar to the power rectifier. They are; (1) the rectifier must be ignited and (2) a relatively high vacuum must be maintained.

Ignition of the rectifier is accomplished by a moving auxiliary electrode. Some schemes use alternating current for the arc starting; some use direct current. When alternating current is used for ignition, two ad-

*COMMITTEE ON AUTOMATIC STATIONS:

Chester Lichtenberg, Chairman.

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C. A. Butcher,	S. J. Lisberger,	E. C. Stone,
M. S. Coover,	G. H. Middlemiss,	L. J. Turley,
W. P. Hammond,	W. H. Millan,	F. Zogbaum.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928. Complete copies upon request.

ditional auxiliary starting electrodes are required. The ignition equipment is fully automatic. It starts the arc as soon as a-c. power is available. It extinguishes the starting arc as soon as the power arc is formed and maintained. It will re-ignite the rectifier automatically if for any reason the power arc is extinguished.

The required vacuum is usually maintained by two pumps. One is a rotary motor-driven oil-sealed mechanical pump; the other a mercury condensation pump. These start and stop in response to vacuum conditions as indicated by a vacuum relay.

Water cooling systems are usually favored for preventing the rectifier temperature rising above a specified maximum. It is controlled by conventional thermal relays connected in the operating sequence of the automatic switching equipment.

The minimum protection recommended for power rectifiers is less than that recommended for synchronous motor generators and synchronous converters, but is greater than that recommended for static transformers, synchronous hydroelectric generators, and synchronous condensers.

Protection against a-c. undervoltage, single-phase starting, and single-phase operation is sometimes required for power rectifier auxiliaries under certain conditions. Protection against severe a-c. over-current is generally required. In the case of power rectifiers, it may be self-resetting, while for rotating machines, it is usually of the lock-out type. This is due to the difference in the inherent characteristics of the two machines. Protection against d-c. reverse current and excess temperature due to sustained overload is provided for the power rectifiers just as for rotating power apparatus. Power rectifiers, unlike most other types of power apparatus, are usually provided with protection against poor vacuum, failure of vacuum pump, and failure of cooling fluid supply.

The starting and stopping of power rectifiers in automatic stations follows the same principles as developed for rotating machines. Some device substitutions are made in the protective circuit to suit the individual characteristics of the rectifiers. Similarly, load-limiting and load-shifting features may be provided just as for rotating machines, particularly synchronous converters.

In general the automatic control for power rectifiers is similar to that for rotating machines, excepting where it has been necessary to develop some special devices to suit the peculiar characteristics of the rectifiers just as it was necessary to develop special devices for some of the peculiar characteristics of synchronous motors, d-c. generators, synchronous converters, and other types of power apparatus.

Supervisory Equipment

Supervisory equipment is rapidly assuming an important place in the design of electric power systems. It is being used not only for the supervision of automatic stations, but for the supervision of important power distribution networks and the operation of large substations and generating stations. The trend is definitely toward a simple system normally at rest. Any operation either to actuate a device or to report an actuation starts a sequence. This usually continues until the operation and report are completed; then the system remains at, or returns to, a position of rest.

Three or four line wires continue as standard for supervisory systems with visual indication of operation and the usual operating currents and frequency. Carrier-current systems use either one or two wires, or, in some cases, are superimposed on power circuits. Each method has a field of application depending upon local conditions and operating requirements.

Several designs of supervisory equipment use the ordinary telephone apparatus and telephone communication circuit for both talking and control, as well as answer back. These have a relatively restricted application.

Reliability of supervisory systems and equipment is only as good as the line wires which are provided. The terminal apparatus may be perfect; it may operate precisely as the designer intended it to operate; yet, if the wires connecting the terminal equipments fail, the entire system is rendered inoperative. It is necessary that this feature of supervisory equipment be taken into account in its application, since it has shown a definite limit for such systems under present day operating conditions.

Telemetering

Telemetering is just coming to be recognized as a distinct necessity in the operation of automatic stations,—particularly those forming part of large electricity supply systems. Developments have been rapid during the past two years. A number of systems are on trial, most of them too elaborate for economical application. Some give promise of meeting the requirements of high accuracy, low cost, reliable operation, and freedom from resistance and other circuit errors.

The telemetering systems now in operation are used for a very wide variety of purposes; some give readings of circuit current and voltages; some give readings of station load; still others are used for transmitting to a central office, the readings of total station loads, and also for again totalizing all the stations on a system and returning this total to each of the contributing stations. Still other systems are used for giving a central dispatcher knowledge of the distribution of demand over a given system. Others serve to adjust the supply of power from two sources in proportion to the load demand required from these two sources.

In another year, operating experience should be available which will permit of a better picture of the trend of this very interesting development being given more definitely.

Carrier Current

Carrier currents in frequencies from 500 cycles to over 50,000 cycles are being used for the operation of supervisory and telemetering systems; some of these are

used in combination with automatic stations, and some are used for the operation of power apparatus in remote stations. Several papers have been presented before the Institute on this subject and the discussion of these papers gives the trend of thought. A great amount of research and development work is being done on this subject and future reports will no doubt give more comprehensive data concerning it.

Operating Experience

Operating experience, particularly that with automatic stations, has formed the subject of several papers presented before the Institute. The art would advance very much more rapidly and more surely should more operating engineers take it upon themselves to present to the membership, through papers read at Regional Meetings, their individual experiences with automatic stations. The manufacturers and designers recognize that each power system has its individual characteristics. These require the fitting of automatic stations, individually to each power system. Notwithstanding this, all systems have a certain similarity. They also have certain operating requirements. The art is handicapped because the designers do not obtain freely from the operators information regarding the system requirements and performance under given conditions. However a number of the operating engineers have contributed richly toward the development of the art by telling of their experiences. It is believed that a broadening of this idea will do much to stabilize the industry.

Maintenance and Inspection

Maintenance and inspection of automatic stations are prime requisites for their successful operation. To obtain a maximum benefit from these stations it is necessary that they be given adequate, systematic, and intelligent inspection. The word "intelligent" really covers the field, for, in a broad sense, it includes the words "adequate" and "systematic."

Much of the development work carried on by the manufacturers has been done with the idea of reducing the necessity for maintenance and inspection to a minimum. The devices and schemes of operation which have been produced from this development render the automatic station a unit in any system, which not only contributes to the economic operation of that system, but which also does much to promote continuity of the service supplied by that system.

Practical analysis verifies the statement that "Nothing is perfect." Any commercial device is a compromise between perfection and cost. The quality of service to be expected is thus necessarily a measure of the maintenance required to effect those things by which a device, or an equipment as a whole, falls short of perfection. If the outage of a unit is not a serious matter, time may be allowed for clearing a failure in the switching sequence. This would normally render the unit inoperative under certain conditions; hence there might be a tendency to neglect the matter of routine inspection or maintenance.

In protective devices, however, the failure which might result in costly damage as well as extended outage is a far more serious matter. For this reason, the automatc station is safeguarded by protective devices not ordinarily found in attended stations. In protecting against equipment failure, one protective device is often reenforced by another, so that only by simultaneous failure of separate and independent protective devices can serious damage be done to the equipment. These protective devices are the product of many years of research, development, and experience. It is necessary, however, that they be used intelligently. If it is to be expected that they will render the service for which they were intended they must be suitably adjusted and adequately maintained.

The importance of continuity of service renders the proper functioning of switching sequence of equal importance with that of protective equipment. A knowledge of the proper functioning of each device and its relation to other devices is the first qualification for one responsible for the inspection or maintenance of an automatic station. Such an individual need not be a technically trained man; in fact, he often is not. He should, however, have a thorough grasp of the fundamentals, and be experienced not only in the operation of the equipment itself, but in the relation of the station to the rest of the system. The latter is especially essential if he is to be able to analyze properly the limitations of the equipment and make adjustments accordingly.

With each equipment the manufacturers usually supply instruction books and diagrams giving a comprehensive analysis of the scheme of operation, as well as detailed information of each device. If he is to give the station the best attention an inspector, or maintainer, should be thoroughly familiar with the contents of the instruction book and wiring diagram.

Sometimes the maintainer overdoes his job in such matters as cleaning and filing of contacts. Relays are usually under covers. Inspection of the parts is facilitated by the use of glass, making the removal of the covers necessary only at infrequent intervals. The removal of oxide from contacts is accomplished by the use of crocus cloth, or cleaning with carbon tetrachloride. Contacts in the power circuits and the heavier duty control circuits, when properly adjusted, will require little or no dressing of the contacts. They should be kept clean and bright. Filing is usually not required, as the contacts wear naturally to better surfaces than may be effected by filing. Unless carefully done, filing tends to make matters worse, and even shortens the life of the contact.

Judicious lubrication of moving parts, cleanliness, and the keeping of wiring connections and interlock adjustments tight are the principal factors having to do with the proper maintenance and inspection.

The frequency of inspection of any particular station is best determined by those in responsible charge of the systems. The experience of others in the operation of similar equipment in like service may be used as a guide, but seldom serves as a standard to be followed, since operating conditions are never identical. A brief experience with an inspection schedule will determine where it should be modified so as to give best results. An inspection report, made in preliminary fashion with mineograph copies, might well be used during the first few months until a definite plan is decided upon. Samples of inspection report forms used by a number of operating companies are now available and may be had upon request to them.

A summation of the situation is given by a member of the committee who has had a number of years of experience in the operation of automatic stations. He states that several years of experience with daily inspection, with no definite routine, did not produce the required results. Railroad equipment is operated on a car or locomotive mileage basis as determined by the conditions. It is then taken into the shop, thoroughly overhauled and sent out on the road subject to a trip of casual inspection somewhere on the road, until it has operated a certain mileage. Then it is returned again to the shop for general inspection. It is logically assumed that after such an inspection, it should cover a predetermined number of miles without attention. The same assumption can be accepted for the inspection of automatic station equipment. There should be a periodic thorough inspection; weekly, on some parts of the equipment and monthly, semi-annually, of annually, on other parts. Rotating equipment may have to be cleaned at intervals of two or three days,—or even longer,—depending upon the number of hours run and conditions of ventilation of the station. The station may have to be visited daily for other reasons than inspection of apparatus where no supervisory equipment is used. With supervisory control, no other attention should be needed than cleaning and periodical inspection.

Standards

A final report on Standards for Automatic Station No. 26 was presented to the Standards Committee at its January 20, 1928 meeting. Following a letter ballot, this report was submitted by the Standards Committee to the Board of Directors with the recommendation that it be approved as an A. I. E. E. Standard. The Board of Directors approved the Standards for Automatic Stations, April 6, 1928.

The Committee on Automatic Stations intends to present revisions of these standards to the Standards Committee from time to time as the necessity for them may arise.

Functional Numbers

Functional numbers have been used for automatic station devices and functions for about 15 years. A gradual standardization has resulted. The latest list is given in the Standards for Automatic Stations recently adopted by the Board of Directors.

The functional numbers initially followed the sequence of operation of the devices. Later, as automatic stations developed, this sequential numbering could not be followed. It resulted in an arbitrary numbering system which has become generally known in the art.

The present numbering system uses a base of not more than two digits. The numbers from 1 to 99 inclusive cover the entire range of basic functions. Numbers in the 100, 200 and other series are used for designating these functions when used with feeders, supervisory systems and the like. The system of numbering the functions, however, still remains arbitrary.

It has been thought that a system of numbering more logical and less arbitrary might be developed. A subcommittee has had this matter under consideration since December 1, 1927 and have rendered several reports. Progress has been made, but a solution has not yet been supplied. It is recommended that a subcommittee be appointed to continue the study of this important topic during the ensuing term.

Papers

Papers presented under the auspices of, or in cooperation with, the Committee on Automatic Stations during the current year have been as follows:

Subject	Author	Place & Date
Operation and Performance of Mercury Arc Rectifiers.	Caesar Antoniono	Chicago—Nov. 1927
Automatic Control of Edison Systems................	O. J. Rotty & E. L. Hough	New York—Feb. 1928
Automatic Switching of Incoming Lines and Transformers................	A. E. Anderson	St. Louis—March 1928
Mercury Arc Rectifier Substations................	G. E. Wood	New Haven—May 1928

Unfinished Business

Topics which have been under consideration by the committee, and concerning which no report has been rendered, are as follows: (1) Ventilation; (2) fire protection; (3) economical construction; (4) unusual operating conditions; (5) load dispatching; and (6) wire designations.

In addition to these items of unfinished business, there are other items upon which reports have been rendered but which do not fully close the subject. These are as follows:

(1) Papers, (2) standards, (3) research, (4) operating reports, (5) remote metering, (6) supervisory control, (7) progress in the art, (8) inspection, (9) functional numbers, and (10) bibliography.

It is recommended that these subjects be given consideration by the succeeding committee.

Bibliography

Many requests have been received from time to time for a bibliography on automatic station literature. Such a bibliography has been prepared and forms an appendix to this report in its complete form.

Abridgment of

Formula for Minimum Horizontal Spacing of Transmission Line Conductors as Affected by Danger of Contact in the Span

BY PERCY H. THOMAS[1]
Fellow, A. I. E. E.

THE present contribution is for the purpose of deriving a logical formula to be used as a guide in the determination of the minimum safe horizontal spacing of transmission line conductors, and is offered for discussion. By minimum safe horizontal spacing is meant the least spacing that will insure safety against short circuits between conductors due to their swinging together out in the span, under the influence of wind or ice, and has no relation to the separation of conductors transversely at the towers, as required for securing the necessary clearance to the tower structure. The latter separation is usually controlling, but a number of cases occur where the getting together in the span requires a wider spacing, such, for example, as long spans or two circuit horizontal arrangements of conductors.

Theoretical Analysis

A study of these questions shows many erratic factors bearing on the danger of contact in the span between cables *horizontally* spaced, so that apparently experience data rather than mathematical calculation must be the final dominating consideration. However, these experience data are exceedingly scanty and difficult to interpret, so that a theoretical analysis is likely to be of real value.

Steady Uniform State

Considering a transverse wind, uniform in direction and steady in strength, we have a very simple case, for all the cables will be deflected in the same direction and by the same amounts, and will maintain exactly the same horizontal separation regardless of the direction and strength of the wind, even if the wind be straight up. And if the wind blows at an angle with the direction of the line, the same condition exists. This is a very important conclusion.

An examination of the relations involved shows that with a strong cross-wind blowing, the dropping of the ice on one cable leaving another cable in the same span coated would not have much effect on the relative side-swing of the two conductors in the case of aluminum cable, steel reinforced, since the weight drops with the ice removed more or less in the same proportion as the wind surface is reduced. A special study should be made in each case for copper cable, where the balance is not so close. This action of steady state side-swing giving unequal displacements from ice unbalance is governed by entirely different conditions from the general case, and is not hereinafter considered.

Non-Uniform Wind Condition

When the wind is irregular in time or direction, or uneven at different points, there will be more or less tendency for the cable to depart from the true catenary curve and the possibility of contact occurs. Obviously, it is the transverse horizontal components of the deflection that tend to cause contact, not the vertical. With a strong wind blowing across the line, say 60 mi. an hour, air moves at a velocity of 88 ft. per sec., so that a time of perhaps 2/10 sec. elapses between the time when the air impulse acts on one cable. When it reaches the next cable in the same horizontal plane, and there is no time for actual motion of one cable ahead of the other cable, due to the same high velocity wind impulse. Furthermore, it is exceedingly unlikely that with a *high velocity* transverse wind, there can be any great change of velocity or direction of the air in traversing the short distance between adjacent cables. In fact, the direction of the air must, in general, be substantially parallel to the ground, as there is no place for air to go elsewhere. This means that all cables in the first approximation are subject to substantially the same transverse air impulses at any one instant of time. This is the reason, no doubt, that trouble with wires getting together in the span is so rare. Where the surface of the ground is curved, or local obstructions exist close to the line, of course eddies will be produced. This is a vitally important case and will be considered later.

The most important active factor in preventing contact in the span with transverse winds is the restraining force of the tension in the cable, which tends to prevent deformations of the catenary by the wind. In long-span construction, this tension is of very material amount and has a remarkable restraining effect. To deflect a vertically-hanging wire, carrying a 5000-lb. weight one degree from the vertical will require a horizontal force of 85 lb. applied at the weight. A wind producing a pressure of 8 lb. per ft. must blow against 10.6 sq. ft. of area to produce such a force. Deflection of a cable from the catenary shape, however, will require much more force than the hanging weight, since both ends of the cable are fixed and it is already a convex curve. Therefore, in accordance with the law

1. Consulting Engineer, New York.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25, 1928. Complete copies upon request.

of increase of tension in a catenary with decrease of sag, (which approaches the action of a toggle joint), the straightening out of other parts of the catenary cable, which must accompany bulges in the curve at any point, develops very high counter tension. A careful consideration of this matter will show that a catenary under wind pressure and with small sag and high tension is a very stable curve against deflection in the plane of the curve.

Furthermore, the swinging of cables will be largely "dead beat" on the wind (at least with transverse winds), and *will have no material pendulum or oscillatory movement.* It will be remembered that as a theoretic conclusion, pendulum action can occur only as the energy stored in momentum carries the moving body beyond a point of equilibrium against an elastic controlling force, thus paving the way for a return swing caused by the controlling force. The *velocity* of movement of the conductor in an actual span is relatively small, so that the kinetic energy stored in the moving cable cannot be sufficient to move it against gravity more than a few inches, and no oscillatory movement of a few inches could be of serious importance in a transmission line. A velocity of one foot per sec. will cause a rise against gravity of only 0.02 ft. A velocity of 8 ft. per sec. would be required for the kinetic energy to be sufficient to raise the cable one foot against gravity. Thus it seems that due to wind across the line, there is little chance of conductors getting together horizontally.

Considering these principles in numerical relations, it may be assumed as an approximation that the danger of the deformation of the catenary and contact between cables is inversely proportional to the cable tension, other things being equal. It may be assumed also that it is directly proportional to the span, for obviously any given proportional deformation will give an actual displacement in feet proportional to the length of the span. Further, the displacing force will be proportional to the diameter of the cable representing the exposed surface.

The tension in any span taken as due to wind and weight will be proportional to the resultant of the wind and weights, w, acting on the cable times the square of the span divided by the sag closely but not exactly.

The danger of contact would then be proportional so far as the above factors are concerned to

$$\text{Span} \cdot \frac{\text{Sag} \cdot \text{Diam.}}{w \cdot \text{Span}^2} = \text{Sag in per cent} \cdot \frac{\text{Diam.}}{w}$$

and might be written for preliminary purposes as

$$\text{horizontal spacing} = C \frac{\text{Diam.}}{w} \cdot \text{Sag in per cent where}$$

C is a constant.

The effect of cable weight is to give greater tension and hence is favorable; but already its effect is included in the formula. The effect of diameter would seem to be relatively unimportant because both the force restraining (tension) and the force causing deformation (wind puffs) are affected more or less alike by diameter. This mathematical expression will be further considered below.

Longitudinal wind will cause a deformation of the catenary in a vertical plane but so long as it is a horizontal wind, it will not tend to cause contact.

The vertical component of any wind, whether transverse or longitudinal, tends to support the weight of the cable and thus reduce the tension which, in turn, tends to render contact in the span more likely and this is probably the principal cause of such trouble. If the uplift is sufficient to take all the weight off the wire, there is tension due only to transverse components of the wind. Under such conditions, minor forces will be largely free to move the conductor about in an accidental manner, rendering contact much more likely. For example, a gusty longitudinal wind blowing under a line up a concave, rising hillside, would be very favorable for trouble, for the wind would have an upward component which would take off the weight and tension on the wires and the irregular transverse components would be free to bring them together.

A 6.5-lb. per sq. ft. upward wind component will take all the weight off a No. 4 copper cable and a 15-lb. wind all the weight off a No. 0000 copper cable.

For all aluminum cable, the respective corresponding pressures are 2-lb. wind and 6.2-lb. wind, and for aluminum cable steel reinforced 2.8-lb. and 6.4-lb. A 2-lb. wind on cylindrical surfaces corresponds to a velocity of 27 mi. per hour actual, and 6-lb. to about 60 mi.

Causes of steady upward components of wind would be configuration of the ground, or natural and artificial obstructions, such as trees, buildings, sign boards, gullies, etc. In any particular case, from an examination of the ground, a sufficiently correct inference as to the directions of air currents can no doubt usually be made.

The breaking off of ice, heavy wind in an adjacent span, or other causes, may produce a pulling of a certain short length of cable from one span into the next, but this will effect danger of contact in the span only indirectly, and whatever conditions might be set up to render the line safe in general against transverse wind conditions in the span would probably protect also against the effect of pulling from one span to another.

Similarly, transverse conductor swinging may be carried from one span to the next, but such swinging is likely to be largely in synchronism for all conductors, unless in cases of very irregular ground configuration.

Apparently relatively short spans and very low stringing tension in the conductor tend to increase danger of contact, especially since it is highly probable that irregular wind and ground conditions do not exist over the whole length of any very long spans. This seems to be confirmed by reports of the behavior of extra long spans.

Wind Puffs and Eddies

No definite measure of wind irregularities seems feasible. We know that air in wind motion will act like water at the bottom of the sea, for air is substantially incompressible for variations of atmospheric pressure. Where a current meets an obstruction, it will be deflected to the side, or upward, with an increased pressure, but without increase of velocity. If a current, however, is directed into a funnel shaped cavity or recess, there may be a somewhat increased velocity. Air seems to be subject to cyclonic effects more than water, but they do not seem to be especially destructive to transmission lines. Presumably, the danger from these puffs and eddies is measurable by the factors already discussed above.

The only way to take account of expected irregular variations in wind action in the proposed formula is to make a purely arbitrary alteration in the factor C for any unusual conditions.

The only clear danger of contact in the span arises when, through deflection by obstacles or a hollow formation of the surface of the ground, there is an upward turn of the wind, tending to raise the wire and thus give it slack within the span for accidental deflections.

Such obstacles and hollow surfaces must lie in the direction of the line, so that a considerable length of span may be affected.

A typical example has been reported in a case where a transmission line paralleled the edge of a wood for a certain distance just outside. At this portion, the conductors were blown together in the span a number of times, presumably with the wind toward the wood. The obvious explanation would be the turning up of the wind strata blowing along the ground when they reached the wood, thus tending to raise the conductors, allowing them to get together through the slack with no strong transverse pull to keep them all to one side.

The conclusion would seem to follow that each line when installed should be gone over for the purpose of locating wind obstructions or hollow shaped earth formation, and special precautions taken to prevent contact of wires wherever such need appeared. It would be uneconomical to increase the width of structures over a whole line to meet a few determinable danger spots.

Since the same spacing must ordinarily be used throughout the line, the constant C should be determined by comparison with experience and should presumably be taken as applicable to the *normal tangent level span under Class A* loading conditions (or any other conditions that might be agreed upon) and it must contain a sufficient factor of safety or margin to cover extra long spans and other variations. The apparent added risk from extra long spans is balanced partly by the much smaller chance of excessive air puffs and eddies on the large scale of the long span.

In choosing an actual formula, certain other considerations may be taken into account.

The jumping distance of the voltage, of course, is a factor to be taken directly.

The effect of the length of the insulator string appears to play little part in any of the above analysis and a long string would not seem to render contact more likely than a short string. Apparently, antics in the middle of the span would not be greatly affected by the length of the insulator string. Nevertheless with our present imperfect knowledge of this subject, we would not be warranted in ignoring the length of insulator string. As an empirical formula it may reasonably be assumed that the horizontal spacing should include a part equal to the side deflection of the insulator string to the 30-deg. position. The normal spacing is certainly not likely to be reduced more than this due to the string. For pin type insulators this part becomes zero.

The above formula may then be set up as follows:

Horizontal spacing $= C$. Sag in per cent.

$$\frac{\text{Diameter cable}}{\text{Class } A \text{ loading}} + D + \tfrac{1}{2} \text{ . Length of insulator string}$$

Where C = A constant chosen arbitrarily for each line to take account of the sort of metal of conductors, wind conditions, character of terrain, etc.

D = Jumping distance of line-voltage—one foot for each 110 kv.

Sag in per cent is expressed without decimals; that is, 2 per cent is written "2."

If C is taken as 4 for copper cable and 3.5 for A. C. S. R. and their sags in the normal span respectively as 3.75 per cent and 3.25 per cent, the spacings for No. 0000 cable would be as follows:

For 44 kv. Pin Type Insulators

No. 0000 Cu. No. 0000 A. C. S. R.

$$4 \cdot \frac{0.5275 \times 3.75}{0.927} + 0.4, \quad 3.5 \cdot \frac{0564 \times 3.25}{0.764} + 0.4$$

$$= 9.0 \text{ ft.} \qquad = 8.8 \text{ ft.}$$

For 66-kv. suspension insulators

ditto $+ 0.6\tfrac{1}{2} \times 2.25 = 10.3$, ditto $+ 0.6 + \tfrac{1}{2} \times 2.25 = 10.1$

For 110-kv.

ditto $+ 1.0 + \tfrac{1}{2} \times 4 = 11.6$, ditto $+ 1.0 + \tfrac{1}{2} \times 4 = 11.4$

For 132-kv.

ditto $+ 1.2 + \tfrac{1}{2} \times 5 = 12.3$, ditto $+ 1.2 + \tfrac{1}{2} \times 5 = 12.1$

For 220-kv.

ditto $+ 2.0 + \tfrac{1}{2} \times 8.0 = 14.6$, ditto $+ 0.2 + \tfrac{1}{2} \times 8 = 14.4$

The above formula is the mathematical equivalent of the following:

In comparing two spans, *the horizontal spacing*, other conditions than those specified being equal,—

Should be twice as great in the first span when both

have the same length, but the conductor in the first has one-half the tension of that in the second:

Should be twice as great in the first span when the first is twice as long and both have the same tension:

Should be the same in both when the first is twice as long and the second has half the tension:

Should be twice as great in the first when the diameter of the cable is twice as great,—the sag, span length and loading per foot being the same in both:

Should be twice as great in the first when the loading is half,—the span length, the sag and the diameter being the same.

In the formula tension and span length are the critical factors, one being as important as the other. The disadvantage of a long span can be made up by a higher tension and vice versa.

As instances of actual lines where an actual comparison can be made with this formula may be mentioned: (1) The Davis Bridge line of the New England Power Company with a two-circuit line of 12-ft. horizontal spacing on 110-kv. for No. 0000 copper wire; (2) a somewhat similar line of the Appalachian Power Company with 10-ft. spacing for 88 kv. for No. 0 copper conductor.

In conclusion, it may be said that as a result of the various considerations already discussed and of an examination of the proposed formula:

1. The safety against contact in the span depends apparently more upon tension in the cable and configuration of the ground than anything else.

2. The most dangerous conditions are probably those in which the general wind velocity is not too high,—this signifying low conductor tension, and is more or less parallel to the line, so that neither cable is blown far to either side,—and in which there is an obstacle causing a local upward turn in the wind. The conditions will be worse in short spans and with small cables and large sags.

3. The cable conditions on side hills deserve much more consideration than they usually get.

4. The advantage of copper over A. C. S. R. or A. C. S. R. over copper, (if either can be established), should be taken into account in the arbitrary constant, C, as should also any variations of the terrain making the general conditions of any one line better or worse than normal

Letters and extracts describing a few very interesting and pertinent cases of actual trouble and seeming definitely to support the conclusions are given in the complete paper.

The official dedication of the new half-million-dollar Engineering Building of Princeton University took place on November 15 in the presence of over 200 scientists and engineers from all parts of the country. Addresses were made by John Grier Hibben, president of the University, Arthur M. Greene, dean of the Engineering School and Dexter S. Kimball, of Cornell University.

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO 220-KV. CONSTRUCTION

The following description of the high-tension construction of the Hydro-Electric Power Commission of Ontario in connection with the power from the Gatineau River is furnished by courtesy of Mr. Arthur H. Hull of the Commission.

On October 1st, 1928, the Hydro-Electric Power Commission of Ontario took delivery of the first block of power from the Gatineau Power Company. The initial amount of power is 80,000 hp. This will be increased yearly until, in 1931, approximately 260,000 hp. will be taken.

The first construction by the Commission comprises a single-circuit 220-kv. 25-cycle transmission line on steel towers approximately 200 mil. long, from the Ottawa Rver near Fitzroy Harbor in Ontario to Leaside adjoining Toronto, and a 90,000-kv-a. transformer station at Leaside. At the Ottawa River, the line joins a similar line constructed by the Gatineau Power Co. in Quebec, extending about 30 mil. to its Paugan development on the Gatineau River.

The transformer station at Leaside contains two banks of three-winding, single-phase transformers, each transformer being rated at 15,000 kv-a. on every winding. Transformation is from 220 kv. to 110 kv. and 13.2 kv. The high- and middle-voltage windings of the bank are star-connected while the low-voltage winding is delta-connected. The neutral of the 220-kv. star is solidly grounded. Under-load tap changers are provided on the 110-kv. windings to provide a change in voltage of 7½ per cent plus and minus. The transformers are of the outdoor water-cooled type and are provided with expansion tanks. Provision is made for adding two additional banks of transformers, for a second 220-kv. transmission circuit, and for the necessary synchronous condensers.

The transmission line conductors are 795,000-cir. mil aluminum cable with 30 per cent steel core horizontally spaced 25 ft. apart and two suspension equipped overhead static cables are installed the entire length of the line. Near the Leaside Station, two additional overhead static cables were provided and the insulator strings reduced from the standard of 18 units to 14 units over this portion. Provision is made for guard rings, these, however, have not yet been installed. A protecting piece of cable is installed at the clamps and vertically above the cable. The ends of this piece of cable are secured to the main cable about three feet from the main clamp. This second clamping may modify the effect of vibration, if it should develop, in each span. Dead end construction has been reduced to a minimum in this construction. Excepting the terminals and provision for subsequent interswitching, if that is found advisable, there are only eight dead ends in two hundred miles. Most of these are involved in railway crossings.

Attractive Winter Convention Program

Live Engineering Activities Covered in Nine Technical Sessions—Other Notable Features are Planned

The Winter Convention to be held January 28-February 1 in New York promises to offer one of the most interesting programs ever presented at a meeting of the Institute. A notable selection of technical papers, a lecture, inspection trips, medal presentations, a smoker, a dinner-dance and special ladies' entertainment are included in the events scheduled. A summarized program is given below and additional details are presented in following paragraphs:

PROGRAM OF WINTER CONVENTION

MONDAY, JANUARY 28

MORNING:	Registration and Committee Meetings
2:00 p. m.	Session on Dielectrics and Electrophysics
8:15 p. m.	Lecture

TUESDAY, JANUARY 29

10:00 a. m.	Session on Cables
2:00 p. m.	Session on Transmission and Lightning
8:00 p. m.	Smoker and Entertainment

WEDNESDAY, JANUARY 30

10:00 a. m.	Session on Protective Devices
2:00 p. m.	Inspection Trips
8:30 p. m.	Medal Presentations

THURSDAY, JANUARY 31

10:00 a. m.	Two Parallel Sessions (a) Communication (b) Induction Motors
2:00 p. m.	Session on Electrical Machinery
7:00 p. m.	Dinner-Dance

FRIDAY, FEBRUARY 1

10:00 a. m.	Session on Electrical Measurement of Non-Electrical Quantities
2:00 p. m.	Session on Instruments and Measurements

Inspection Trips

A large number of very interesting trips are being arranged. Wednesday afternoon, January 30, has been set aside for trips though several of the trips may be made on any day of the convention. Tickets must be secured in advance for all trips. This requirement has been made necessary by the increasingly large number of those who make trips at the Winter Conventions. Further information on the places to be visited and the manner of registering will be published in later announcements.

Lecture

A prominent speaker will deliver a lecture on the evening of Monday, January 28, on a subject to be announced later.

Medal Presentation

Two medals for achievements in electrical engineering will be presented on Wednesday evening, January 30. These are the Edison Medal and the Lamme Medal.

Entertainment

The lighter side of the convention program will include a smoker on the evening of January 29, a dinner-dance on January 31 and additional entertainment for the ladies.

The smoker will be held this year in the Engineering Societies Building. The ample and comfortable seating facilities of the Auditorium will be used for the presentation of the entertainment features after which a buffet supper will be served on an adjacent floor. It is very desirable that those who plan to attend the Smoker register and obtain tickets in advance so that satisfactory arrangements can be made for the supper.

The annual Dinner-Dance will be held as in the past at the Hotel Astor. This popular event needs no introduction to Institute members and it is necessary only to say that the committee in charge promises that it will be as enjoyable as the former dinner-dances.

A special program of entertainment for the lady guests is being planned. A committee is working on plans for teas, trips, etc., which will allow the ladies to become acquainted and provide for their pleasure during the convention.

Reduced Railroad Rates

Reduced rates for railroad transportation will be available under the certificate plan to members and guests who attend the Convention.

Committees

The general 1929 Winter Convention Committee is as follows: H. A. Kidder, Chairman; J. B. Bassett, H. P. Charlesworth, W. S. Gorsuch, G. L. Knight, E. B. Meyer, H. S. Sheppard, C. E. Stephens and R. H. Tapscott. The chairmen of the subcommittees are: *Entertainment*, J. B. Bassett; *Dinner-Dance*, C. R. Jones; *Inspection Trips*, F. Zogbaum, and *Smoker*, J. F. Fairman.

Technical Sessions

The technical papers have been selected from a great number of available contributions. They deal with some very live topics under the general headings shown below. It should be noted that the titles of papers listed include only those papers which had been accepted when this JOURNAL went to press (November 20). Other papers are being considered and those acccepted will be listed in later announcements.

SESSION ON DIELECTRICS AND ELECTROPHYSICS
January 28

This session will contain probably five papers dealing with dielectric absorption, power factor and dielectric constant of viscous dielectrics, breakdown of air gaps at high voltages, corona ellipses, and flux linkages. The accepted papers to date are as follows:

Anomalous Conduction as a Cause of Dielectric Absorption, J. B. Whitehead and R. H. Marvin, Johns Hopkins University

Flux Linkages and Electromagnetic Induction, L. V. Bewley, General Electric Co.

Corona Ellipses, V. Karapetoff, Cornell University

Power Factor and Permittibility in Viscous Liquid Dielectrics, D. W. Kitchin, Simplex Wire & Cable Co.

SESSION ON CABLES
January 29

Five papers are contemplated for this session. These are on the subjects of high-voltage cable development and research, ionization studies in paper-insulated cables, and elimination of losses and sheath voltages in single-conductor cables. The accepted papers are as follows:

High-Tension Underground Cable Research and Development, G. B. Shanklin and G. M. McKay, General Electric Co.

Some Problems in High-Voltage Cable Development, E. W. Davis and W. N. Eddy, Simplex Wire and Cable Co.

Ionization Studies in Paper-Insulated Cables—II, C. L. Dawes, H. H. Reichard and P. H. Humphries, Harvard Engineering School

Bonding of Single-Conductor Underground Cables for Elimination of Sheath Losses and Reduction of Sheath Voltage, Herman Halperin and K. W. Miller, Commonwealth Edison Co.

Losses in Armored Single-Conductor Lead-Covered Cable, O. R. Schurig, H. P. Kuehni and F. H. Buller, General Electric Co.

Session on Transmission and Lightning

January 29

Lightning researches in the field and in the laboratory, and the theory of traveling electric waves will be the subjects covered in the five papers planned for this session. The accepted papers are as follows:

A Graphical Theory of Traveling Electric Waves between Parallel Conductors, V. Karapetoff, Cornell University

Progress in Lightning Research in the Field and the Laboratory, F. W. Peek, Jr., General Electric Co.

1927 Lightning Experience on 132-Kv. Transmission Lines, Philip Sporn, American Gas & Elec. Co.

Theoretical and Field Investigations of Lightning, C. L. Fortescue and J. H. Cox, Westinghouse Electric & Mfg. Co.

Protection of Transmission Lines from Interruption by Lightning, by 1927-28 Subcommittee of Power Transmission & Distribution Committee

Session on Protective Devices

January 30

An oil-less heavy-duty circuit breaker—its theory, construction and test—is the subject of three papers planned for this session, and the fourth paper will be on automatically reclosing high-speed d-c. breakers. The following papers have been already accepted:

Theory of the Deion Circuit Breaker, Joseph Slepian, Westinghouse Electric & Mfg. Co.

Structural Development of the Deion Circuit Breaker, C. R. Dickinson and B. P. Baker, Westinghouse Electric & Mfg. Co.

Field Tests on the Deion Circuit Breaker, B. G. Jamieson, Commonwealth Edison Co.

Automatic Reclosing High-Speed Circuit Breaker Feeder Equipment for D-C. Railway Service, A. E. Anderson, General Electric Co.

Session on Communication

January 31

Applications of radio in aviation, influence of moisture and impurities in textile insulations, application of purified textile insulation to central-office wiring, and vector representation of wave filters are the subjects contemplated for this session. The following papers are now accepted:

Influence of Moisture and Electrolytes upon Textiles as Insulators, R. R. Williams and E. J. Murphy, Bell Telephone Laboratories

Purified Textile Insulation for Telephone Central-Office Wiring, H. H. Glenn and E. B. Wood, Bell Telephone Laboratories

Vector Representation of Wave Filters, R. F. Mallina and O. Knacknuss, Victor Talking Machine Co.

Session on Induction Motors

January 31

The capacitor motor, low-starting-current induction motors, and calculation of no-load core losses are the subjects of the five papers planned for this session. The following have been accepted:

The Condenser Motor, B. F. Bailey, University of Michigan

The Fundamental Theory of the Capacitor Motor, H. C. Specht, Westinghouse Electric & Mfg. Co.

The Revolving-Field Theory of the Capacitor Motor, W. J. Morrill, General Electric Co.

Line-Start Induction Motors, C. J. Koch, General Electric Co.

Calculating No-Load Core Losses in Induction Motors, Thomas Spooner, Westinghouse Electric & Mfg. Co.

Session on Electrical Machinery

January 31

Five papers are planned for this session dealing with insulation tests on electrical machinery before and after placing in service, influence of temperature on commutators, transient conditions in electrical machines and transformers, and the two-reaction theory of synchronous machines. The accepted papers are the following:

Insulation Tests of Electrical Machinery Before and After Being Placed in Service, C. M. Gilt, Brooklyn Edison Company and B. L. Barns, Canadian General Electric Company

Influence of Temperature on Large Commutator Operation, F. T. Hague and G. W. Penney, Westinghouse Electric & Manufacturing Company

Effect of Transient Voltages on Power-Transformer Design, K. K. Palueff, General Electric Company

Transient Analysis of A-C. Machines, Yu H. Ku, Massachusetts Institute of Technology

Two-Reaction Theory of Synchronous Machines—Part I, R. H. Park, General Electric Company

Session on Electrical Measurement of Non-Electrical Quantities

February 1

Magnetic analysis of materials, measurement of fluid flow, use of the oscillograph in measuring non-electrical quantities, study of noises in electrical apparatus, and application of electricity to navigation are the subjects proposed for this session. The accepted papers are shown below:

Magnetic Analysis of Materials, R. L. Sanford, U. S. Bureau of Standards

Use of the Oscillograph for Measuring Non-Electrical Quantities, D. F. Miner and W. B. Batten, Westinghouse Elec. & Mfg. Co.

Study of Noises in Electrical Apparatus, Thomas Spooner and J. P. Foltz, Westinghouse Electric & Mfg. Co.

Session on Instruments and Measurements

February 1

Totalizing meters, remote metering, high-accuracy current transformers, a 132-kv. shielded potentiometer, and a precision regulator for alternating voltage are the subjects proposed for this session. The following are the accepted papers:

Telemetering, C. H. Linder, H. B. Rex and C. E. Stewart, General Electric Co.

Totalizing of Electric System Loads, P. M. Lincoln, Cornell University

A New High-Accuracy Current Transformer, M. S. Wilson, General Electric Co.

132-Kv. Shielded Potentiometer for Determining the Accuracy of Potential Transformers, C. T. Weller, General Electric Co.

A Precision Regulator for Alternating Voltage, H. M. Stoller and J. R. Power, Bell Telephone Laboratories.

Future Institute Meetings

In addition to the Winter Convention, three other Institute meetings are scheduled for the first half of the year 1929. These are two Regional Meetings and the Summer Convention.

March 20-22, a three-day Regional Meeting will be held in Cincinnati, Ohio, under the auspices of the Middle Eastern District.

Dallas, Texas, will be the seat of another Regional Meeting to be held by the South West District May 7-9.

The Summer Convention will be held at Swampscott, Mass., June 24-28.

Plans for all of these meetings are going ahead. More complete information on them will be published at later dates.

Methods of Refrigeration to be Demonstrated before New York Electrical Society

On the evening of Wednesday, December 12 the New York Electrical Society will hold a meeting the subject of which will be "Cold at Home." The speaker Stephen Bennis, Power Engineer, United Electric Light and Power Company of New York will tell how the new gas and electric household refrigerators operate. His talk will be accompanied by experiments with super-cold by liquid air and special working models of the refrigerators will be on exhibit. The meeting will be held in the Engineering Auditorium, 29 West 39th St., New York City, on Wednesday evening, December 12, at 8:15 p. m. All those interested in refrigeration are cordially invited to be present as guests of the Society.

A. I. E. E. STANDARDS

NEW STANDARDS AVAILABLE

One new A. I. E. E. Standard, one revised Standard and six Specifications have just become available.

The new Standards, 17gl, "Standards for Letter Symbols for Electrical Quantities," was developed by a subcommittee of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations working under the procedure of the American Standards Association.

The remainder of the new group all deal with the wire and cable field. The first is a revision of No. 30, "Standards for Wires and Cables." The new edition contains the revised definitions as developed by the Institute, and which will shortly be presented for approval as American Standard. The remaining six are Specifications and are published in three pamphlets. The first group, Nos. 60 and 61, are "Specifications for Tinned Soft or Annealed Copper Wire" and "Specifications for Soft or Annealed Copper Wire." The second pamphlet, No. 63, contains "Specifications for 30 per Cent Rubber Insulation for Wire and Cable for General Purposes." The third pamphlet covers Nos. 69, 70 and 71, "Specifications for Cotton covered Round Copper Magnet Wire," "Specifications for Silk Covered Round Copper Magnet Wire" and "Specifications for Enameled Round Copper Magnet Wire." All this group of Specifications has been developed by the Sectional Committee on Insulated Wires and Cables under the sponsorship of the Institute and nine other bodies. The material contained in the Specification pamphlets is of a radically different nature from that heretofore covered by A. I. E. E. Standards but has been published by the Institute in order to make the valuable work of the Sectional Committee available to industry at an early date.

Available Adopted Sections

A Complete List of the Available A. I. E. E. Standards, Showing Date of Latest Edition, Prices, etc., Follows:

No. 1	(April, 1925)	General Principles upon which Temperature Limits are Based in the Rating of Electrical Machinery. Price 20 cents.
4	(May, 1928)	Standards for the Measurement of Test Voltages in Dielectric Tests. Price 30 cents.
5	(July, 1925)	Standards for Direct-Current Generators and Motors and Direct-Current Commutator Machines in General. Price 40 cents.
7	(Dec., 1927)	Standards for Alternators, Synchronous Motors and Synchronous Machines in General. Price 40 cents.
*8	(Mar., 1925)	Standards for Synchronous Converters. Price 40 cents.
9	(June, 1927)	Standards for Induction Motors and Induction Machines in General. Price 40 cents.
10	(July, 1925)	Standards for Direct-Current and Alternating Current Fractional Horse-Power Motors. Price 30 cents.
*11	(July, 1925)	Standards for Railway Motors. Price 30 cents.
13	(Aug., 1925)	Standards for Transformers Induction Regulators and Reactors. Price 40 cents.
*14	(Mar., 1925)	Standards for Instrument Transformers. Price 30 cents.
*15	(May, 1928)	Standards for Industrial Control Apparatus. Price 40 cents.
*16	(July, 1925)	Standards for Railway Control and Mine Locomotive Control Apparatus. Price 40 cents.
*17f	(Feb., 1928)	Standards for Mathematical Symbols. Price 30 cents.
17g1	(Oct., 1928)	Standards for Letter Symbols for Electrical Quantities. Price 20 cents.
19	(July, 1925)	Standards for Oil Circuit Breakers. Price 30 cents.
22	(July, 1925)	Standards for Disconnecting and Horn Gap Switches. Price 30 cents.
26	(April, 1928)	Standards for Automatic Stations. Price 30 cents.
30	(Oct., 1928)	Standards for Wires and Cables. Price 40 cents.
33	(Jan., 1927)	Standards for Electrical Measuring Instruments. Price 30 cents.
34	(June 1922)	Standards for Telegraphy and Telephony. Price 30 cents.
*36	(Feb., 1928)	Standards for Storage Batteries. Price 20 cents.
*37	(July, 1925)	Standards for Illumination. Price 30 cents.
38	(Mar., 1925)	Standards for Electric Arc Welding Apparatus. Price 40 cents.
39	(Aug., 1926)	Standards for Electric Resistance Welding Apparatus. Price 30 cents.
41	(July, 1925)	Standard for Insulators. Price 30 cents.
*42	(Dec., 1923)	Standard Symbols for Electrical Equipment of Buildings. Price 20 cents.
45	(June, 1927)	Recommended Practise for Electrical Installations on Shipboard (Marine Rules). Price $1.50.
*46	(May, 1927)	Standards for Hard Drawn Aluminum Conductors. Price 20 cents.
*60	(Sept., 1928)	Specifications for Tinned Soft or Annealed Copper Wire.
*61	(Sept., 1928)	Specifications or Soft or Annealed Copper Wire. (No. 60 and 61 published as one pamphlet.) Price 30 cents.
*63	(Sept., 1928)	Specifications for 30 Per Cent Rubber Insulation for Wire and Cable for General Purposes. Price 30 cents.
*69	(Sept., 1928)	Specifications for Cotton Covered Round Copper Magnet Wire.
*70	(Sept., 1928)	Specifications for Silk Covered Round Copper Magnet Wire.
*71	(Sept., 1928)	Specifications for Enameled Round Copper Magnet Wire. (No. 69, 70 and 71 published as one pamphlet.) Price 30 cents.

*Approved by A. E. S. C. as American Standard.
(50 per cent discount to Institute members from above prices.)

Electrical Definitions. The desirability of developing a single recognized publication dealing with electrical definitions has been evident for many years. This project is now taking definite form through the authorization of a Sectional Committee under the procedure of the American Standards Association. The A. I. E. E. has been designated sole sponsor for the project which will have the following scope: "Definitions of technical terms used in electrical engineering, including correlation of definitions and terms in existing standards." The work involved in setting up, what will probably become a dictionary of electrical terms, is very great and it will be a considerable period after the committee is established before their report will be ready for approval as American Standard.

Mercury Arc Rectifiers. The development of Standards for Mercury Arc Rectifiers is a project about to get under way. The makeup of the Sectional Committee, under the sponsorship of the Institute is about finished. As soon as a preliminary draft outlining the proposed American Standard is completed the first meeting will be called and work of developing standards allocated.

Atlanta Holds Notable Regional Meeting

MARKED BY EXCELLENT ATTENDANCE, INTERESTING TECHNICAL SESSIONS, STUDENTS MEETING, AND ENJOYABLE INTERTAINMENT FEATURES

The first regional meeting of the Southern District of the Institute, held at the Biltmore Hotel in Atlanta, October 29-31, proved to be a most successful gathering with an attendance of about 400 at the technical sessions, and over 600 at a general evening meeting. Technical sessions, a student meeting, two lectures, inspection trips, and a dinner-dance were well attended and enjoyed.

Coordinated power-system development, power-limit and short-circuit tests, power-line carrier communication, high-voltage flashovers and electric drive for textile mills, were the chief topics covered in the technical sessions. A summarized report of the discussion at these sessions is given below.

A student session was held on the first morning of the meeting, a report of this being given in the Student Activities department of this issue.

Two most interesting lectures were given. The first of these was by J. B. Taylor of the General Electric Company, who spoke on *Translations between Sound and Light*, illustrating his talk with interesting demonstrations. The second lecture, on the subject of *Science and Research in Telephone Development*, was given by S. P. Grace of the Bell Telephone Laboratories, Inc. He gave with his talk a number of most attractive and unusual demonstrations.

Inspection trips were made to stations of the Georgia Power Company, to a telephoto installation of the Southern Bell Telephone and Telegraph Company, and to Stone Mountain, where a huge Confederate memorial is being carved on the face of what is probably the largest piece of granite in the world.

A dinner-dance was the high spot of the social features which was heartily enjoyed. The lady guests at the meeting also were entertained with a number of drives, teas, and card parties.

SUMMARY OF TECHNICAL SESSIONS

In the following paragraphs is given a summarized report of the technical sessions of the meeting.

Power Developments Session

The session on Power Developments on Monday afternoon, October 29, was presided over by C. O. Bickelhaupt, Vice-President, A. I. E. E., in the Southern District. At this session the following papers were presented:

Economies in Central Power Service, by W. S. Lee.

Southeastern Power and Light Company's System, by A. T. Hutchins.

In the ensuing discussion W. E. Mitchell emphasized the necessity for developing plants for best economic efficiency in distinction to fuel efficiency. In discussing the Hutchins paper, W. S. Lee stated that his company decided on the same type of plant for the River Bend Station as the Alabama Company steam station No. 4, choosing 450-lb. boiler pressure instead of 1200-lb. because the boiler equipment costs 15 per cent less. Although the higher pressure would use 13 per cent less coal, the lower pressure is more economical on account of the smaller investment charges. The use of higher pressures, he stated, seems to offer great promise for the future, but at present they are not economical except for continuous non-varying loads.

Carrier Communication on Power Lines

Power-line carrier communication and supervisory control were discussed at the Tuesday morning session, at which W. S. Rodman presided. The following two papers were first presented:

Carrier Current and Supervisory Control on Alabama Power Company's System, by E. W. Robinson and W. I. Woodcock.

Transmission of High-Frequency Currents for Communication over Existing Power Networks, by C. A. Boddie and R. C. Curtis.

In discussing these papers, C. F. Boeck suggested that equipment for communication over power lines should give reliability even if this requires sacrifice of some simplicity. He believed that the best system from the standpoint of reliability and other merits, is the single-frequency, single-sideband system.

L. E. Anderson urged that manufacturers of carrier equipment cooperate with each other so that one system will not render inoperative an adjacent system made by another manufacturer. He stated that on his company's lines one system is sometimes paralyzed by another higher powered system operating on lines as far away as 400 miles.

L. G. Huggins drew attention to a unique method of charging storage batteries used at remote points on the Alabama Power Company's system. The batteries are charged by a trickle charger having a dry rectifier, the charger being energized by alternating current drawn from a secondary winding on the drainage coil connected to the overhead ground wire of the transmission line.

R. G. McCurdy pointed out a number of advantages in employing a frequency above 50,000 cycles for power-line communication. Among the advantages in using higher frequencies are that cross talk is reduced, the action of choke coils is better and the inductive effect on adjacent telephone lines is diminished as these telephone lines operate below 50,000 cycles.

C. A. Boddie commenting on Mr. Boeck's discussion, stated that simplicity and reliability usually go together. He said that he believes the adoption of the single-frequency, single-sideband system is a move in the wrong direction, and that the two-frequency, double-sideband system is giving very good results for both the Alabama Power Company and the Pacific Gas & Electric Co.

High-Voltage Flashovers

The last two papers in this session were as follows:

Impulse Flashover of Insulators, by J. J. Torrok and W. Ramberg.

A Study of High-Voltage Flashovers, by J. T. Lusignan, Jr.

In a written discussion, A. O. Austin pointed out many features in connection with insulator flashover, and stated that the first impulse of dissipation of energy is very large and is possibly so rapid that it cannot be followed by the cathode-ray oscillograph.

E. H. Rowland claimed that experience has proved that continuous rings at top and bottom of an insulator string give the best protection and that a flat-strap ring gives better protection against steep impulses than a ring of circular or oval cross section.

In a written discussion, W. A. Kates and E. D. Tanzer said that in making flashover tests the amount of energy available in the test set should be considered when drawing conclusions

on actual line conditions where the amount of energy is very large.

A written discussion by L. E. Reukema gave a physical explanation of many of the test results recorded in Dr. Lusignan's paper.

Textile Session

A session on electric drive in textile mills was held on Wednesday morning, at which C. A. Collier presided. The following papers were presented:

Variable-Speed Spinning of Cotton Yarns, by E. A. Untersee.

Motor Drives for Cards and Roving Frames, by H. W. Reding.

Electrification of the Textile Industry in the Southeast, by E. M. Clapp and A. G. Stanford.

H. W. Reding in discussion the first paper presented calculations which showed that application of the variable-speed drive will pay for itself by means of the increased production, but he pointed out that the most important advantages are the improved quality of yarn produced and the larger amount of yarn which can be wound on each bobbin. E. S. Lammers, E. M. Clapp, C. A. Collier and E. A. Untersee agreed with him on the advantage of better quality. In discussing electrical drive in textile mills in general, J. W. Fox emphasized the fact that continuity of service is by far the most important factor from the standpoint of the mill owner. The stopping of machines, he said, costs mill operators thousands of dollars in lost production. J. M. Oliver pointed out that most interruptions are caused by momentary voltage dips on the transmission lines, which dips operate the instantaneous undervoltage relays on the mill motors. He recommended the use of time-delay relays to overcome this trouble. E. F. Pearce in following this point told that the Georgia Power Company had made tests at several mills and found that in the worst case the mill machine may be subjected to a delay of four seconds without damage to machine or product when the power comes back on the line. He pointed out that in the majority of cases of voltage dip, relays set for a delay of 1 second to 1½ seconds will keep the machines in operation.

In the discussion on the last two papers, two advantages of individual electric drive were emphasized in addition to numerous advantages mentioned in the papers. These were the advantages of cleanliness and of safety to the operators. C. A. Collier pointed out that the power factor of individual drives is rather low and that power factor correction becomes important when a large load of individual drives is assumed by a power company.

Power-System Operation

The last session of the meeting held on Wednesday afternoon dealt with power-limit and short-circuit tests, automatic oscillographs and glow-discharge and photoelectric devices. Four papers, as indicated below, were presented in this session, at which W. E. Mitchell presided.

Power-Limit Tests on Southeastern Power and Light Company's System, by S. M. Jones and Robert Treat.

Application of Auto-Oscillograph Equipment for Power Systems, by A. Dovjikov.

Photo-Electric and Glow-Discharge Devices, by J. V. Breisky and E. O. Erickson.

Short-circuit Testing on Alabama Power Company's System, by H. J. Scholz and C. B. Hawkins.

In discussing the first paper, A. Dovjikov questioned the accuracy of the wattmeter measurements which were reported. Robert Treat assured him that these measurements had been checked in several ways and he thought that they were reliable.

In discussing Mr. Dovjikov's paper, E. E. George stated that quick-trip ammeters have been found very helpful in making rapid analysis of system troubles. With these ammeters, the records are instantly available and there is no delay such as is necessary for the development of oscillograph films. Mr. Dovjikov pointed out that though these ammeters are useful as fault indicators, they do not give accurate numerical values.

In connection with the last paper, E. E. George said that the Tennessee Power Company has made many tests by throwing short circuits directly on its system with only one failure of major equipment. These tests have been very valuable, he said, in determining the correct protective equipment. Raymond Bailey outlined some experiences the Philadelphia Electric Company has had with faults on 220-kv. lines and suggested that the remedy for such troubles seems to be the development of a high-speed 220-kv. circuit breaker.

The marked success of this meeting reflects great credit on those who planned and conducted it, including many whose names cannot be published here for lack of space. The General Committee, which had direction of the meeting, is as follows: C. O. Bickelhaupt, Vice-President A. I. E. E. in Southern District, Chairman; T. H. Landgraf, Vice-Chairman; C. E. Bennett, G. N. Brown, H. A. Coles, Rawson Collier, F. M. Craft, C. L. Emerson, T. W. Fitzgerald, E. H. Ginn, E. S. Hannaford, W. E. Mitchell, O. O. Rae, D. H. Woodward and G. J. Yundt.

John W. Lieb is Made Officer of the Legion of Honor

The French Government has bestowed upon John W. Lieb, Senior Vice-President of The New York Edison Company and Past-President of the Institute, the decoration of Officer of the Legion of Honor in recognition of the services rendered in furthering professional and industrial cooperation between French and American Engineers and for facilitating the interchange of knowledge and experience regarding the construction and operation of central station systems for the generation and distribution of electrical energy for light, heat, and power. Insignia of the decoration was presented to Doctor Lieb in behalf of the principal heads of the French electrical industry at an informal dinner tendered at Vanderbilt Hotel, November 2, 1928, by G. Girousse, President of the Société Nord Lumiére and head of a delegation of French Central Station executives and engineers which has been visiting the prominent electric installations of the United States.

Gano Dunn is Elected Alumni Trustee of Columbia

Announcement is made of the election of Gano Dunn (President of the Institute 1911-12), as an alumni trustee of Columbia University. Mr. Dunn, who was nominated by the alumni to serve six years, is a member of the School of Mines class of 1891 and succeeds Walter H. Aldridge, a Mines graduate of 1887. This makes two of the six alumni trustees members of the engineering profession, the other being H. Hobart Porter, President of the American Water Works and Electric Company. General William Barclay Parsons, a life trustee and chairman of the Board, is also an engineer.

Mr. Dunn, now President of the J. G. White Engineering Corporation and a trustee of Barnard College and Cooper Union, recently retired from the chairmanship of the National Research Council. He is a Past-President of the New York Electrical Society and of the John Fritz Medal Board of Award; was chairman of the Engineering Foundation, established by Ambrose Swasey to carry on engineering research, has been a representative of the American Society of Mechanical Engineers on the American Engineering Council, has held membership on several international boards and commissions, and been a delegate to scientific congresses both here and abroad. He was a member of the War Department Nitrate Commission during 1916-1918, and chairman of the State Department's special commission on submarine cables in 1918. He is one of a group of Prof. Michael I. Pupin's students who have attained distinction, and is founder of

the Gano Dunn Prize in electrical engineering, awarded annually by the Columbia Schools of Mines, Engineering, and Chemistry.

Increased Enrollment in Engineering Schools

The Bureau of Education, Department of Interior, has recently announced that the enrollment in 148 engineering schools in the United States has increased from 62,312 in 1926-27 to 65,520 in 1927-28.

The ranking schools in regard to the number of enrollments were: Massachusetts Institute of Technology, 2250; Purdue University, 2226; University of Illinois, 1820; Georgia School of Technology, 1596; University of Michigan, 1593; Ohio State University, 1546; University of Cincinnati, 1565; Lehigh University, 1510; Northeastern University, 1471; Pennsylvania State College, 1444; Agricultural & Mech. College of Texas, 1441; Rensselaer Polytechnic Institute, 1414, with the professional grouping from these institutions giving the following numerical results:

Electrical Engineering, 20,210; civil, 14,073; mechanical 11,273; chemical, 5987; architectural, 3256; mining and metallurgy, 2143, and industrial and commercial, 2135.

Progress in Air Mail Service

It is announced by B. R. Van Leer, Asst. Secy., A. E. C. and Editor of the *A. E. C. Bulletin*, that the air mail service now has 24 lines operated by 22 private companies which have flying schedules from Montreal, Canads, to Mexico City and Havana, Cuba. There are about 140 companies at present manufacturing airplanes in the United States, which is a larger number than those manufacturing automobiles.

On September 27 the government had completed the transfer of all of its air mail lines to private contractors. There is now expended annually over $100,000,000 in the airplane industry.

U. S. A. Corps of Engineers Reports on Bridges

The Corps of Engineers, U. S. A., under General Edgar Jadwin has issued through the Government Printing Office, a 481-page book entitled "A List of Bridges Over the Navigable Waters of the United States." Approximately 6000 bridges are listed from information prepared by the various district engineers of the Engineering Department. For these 6000 bridges, the following information is given: Location, nearest town or street, miles above mouth of the river, owner, kind of bridge, number of spans, clear with normal to channel, clear height of lowest point of superstructure, and the dates of the mean low water and high water, when and by whom authorized by law, date of approval by War Department, date completed, operating requirements and purposes for which bridges are used. This book promises to be a most valuable contribution to the engineering profession.

AMERICAN ENGINEERING COUNCIL

DISBURSEMENT OF FEDERAL FUNDS

The American Engineering Council has "recommended endorsement of the principle of a provision for the expenditure of Federal funds on public works already authorized to increase employment in time of extraordinary depression of private industry, provided such expenditure can be carried through without any increase of taxation." Through its Administrative Board, it has acted upon the legislation proposed at the last session of Congress by Senator Jones of Washington, contemplating the creation of a prosperity reserve for the stabilization of industry and employment by the expansion of public works during periods of industrial depression or unemployment.

In making the announcement, President A. W. Berresford made public a letter relative to the Jones bill from Senator Vandenberg of Michigan to Major Williams, member of the Board, in which he stated that he anticipated that the result of special investigation of the Senate Committee on Education and Labor into all phases of unemployment would recommend an expansion of the "prosperity reserve" doctrine, as the present bill, in his estimation, is not sufficiently far reaching in not providing emergency methods for financing public works.

President Berresford announced that the Council is opposed to the plan of Senator Wagner of New York to establish a national employment service in cooperation with the States, primarily because the matter of employment bureaus is a local and state function, and that it would be a waste of public funds for the Federal Government to get the States to establish such agencies, or, in lieu thereof, for the Federal Government to operate employment bureaus in such States or elsewhere. The engineers felt that to establish a nationwide agency would only create a large number of additional jobs without actually affecting the real employment question when it exists. In a letter to the Executive Secretary of the Council, Senator Wagner disclaimed any political motive in this connection and requested the opinion of the engineers. A bill sponsored by him for improvement in statistics, and which was disapproved by the Council, held that this purpose could be accomplished by the Department of Labor with funds and facilities now available, and that the creation of a new bureau was needless. The Council urged the establishment of a National Hydraulic Laboratory in the Bureau of Standards, an inventory of the water resources of the United States, the transfer of Federal public works functions to the Department of the Interior, topographic mapping to aid in the solution of flood problems and uniform requirements affecting Government contracts. The action of Congress to compel the use of steel cars in railway post office service was opposed by I. E. Moultroup, Vice-President of the Council, upon the grounds that it seemed to him unfair to put this extra burden upon the carrying companies when he believed it was more than probable that steel cars would be made a part of their standard equipment just so soon as the companies could afford them. The Council favored a change in the Amendment to the Flood Control Act to provide for a permanent Mississippi Flood Control Board with a majority of members civilian engineers to review and adjust differences in Jadwin and Mississippi River Commission plans; this board to cease to function with the presentation of its report to Congress. Senator Frazier of North Dakota has a bill which he intends to push at the winter session of Congress, providing a Flood Control Board to consist of Chief of Engineers, the President of the Mississippi River Commission, and nine disinterested civilian engineers to be named by the President.

The American Engineering Council plans to increase public service activities during 1929 and will map out a program at its Annual Meeting to be held at Washington, January 14-15, 1929.

American Standards Association Established

Unanimous approval by the thirty-seven member bodies of the establishment of the American Standards Association to succeed the American Engineering Standards Committee, is announced by William J. Serrill, Assistant General Manager of the United Gas Improvement Company of Philadelphia. Mr. Serrill was chairman of the Standards Committee, and now becomes President of the American Standards Association. According to Mr. Serrill, one of the most important results of the abandonment of the committee form of the organization will be a much broader of participation by trade associations in the direction of the national industrial standardization movement.

One of the new Association's first acts will be to organize a board of directors composed of twelve industrial executives. This newly created board, established in recognition of the increasing part which executives are playing in the stand-

ardization movement, will control the general administration and policies of the Association. The old Main Committee, composed of representatives of all the member bodies, now becomes the Standards Council, and in its hands will rest all matters connected with the adoption and approval of national standards.

In addition to Mr. Serrill, the officers of the Association are: Vice-President, Cloyd Chapman: Secretary, P. G. Agnew; and Assistant Secretary, F. J. Schlink. The advisory committee of Industrial Executives includes: J. A .Farrell, President of the U. S. Steel Corporation, Chairman; George B .Cortelyou, President of the Consolidated Gas Company; John W. Lieb, Senior Vice-President of the New York Edison Company; L. F. Loree, President of the Delaware & Hudson Company; and Gerard Swope, President of the General Electric Company.

International Aviation Conference

Under the sponsorship of the Department of Commerce, there is to be held in Washington, December 12 to 14, the first International Civil Aeronautics Conference. The Department of State has issued invitations to 54 countries, asking each to be represented at the conference by a delegation. World problems relating to aircraft in commerce and trade will be discussed at this conference.

The Executive Committee in charge is headed by Chairman William P. MacCracken, Jr., Assistant Secretary of Commerce for Aeronautics. The Program Committee is in charge of Starr Truscott, Chairman; Finance Committee, Harry Guggenheim Chairman; Entertainment and Transportation, Maj. Clarence Young, Chairman; Printing Committee, Hon. W. Irving Glover, Chairman; Publicity, Chance Vought, Chairman; Escort and Reception, Lieut. Col. R. H. Williams, Chairman; Credentials, Sydney Y. Smith, Chairman; Hotel Reservations, D. A. Skinner, Chairman.

PERSONAL MENTION

Bailey Townshend, formerly Secretary of Engineering of the International Business Machines Corporation, has joined the Research and Development Division of Johns-Manville, Inc., as physicist.

R. J. Keogh, formerly assistant engineer of the Western Electric Company was appointed chief engineer, of the Walbert Mfg. Co. under Bryon Minnium when Mr. Minnium became director of research at Stewart Warner Corp.

Clyde R. Keith has resigned from the Research Department of Bell Telephone Laboratories, New York City, and has accepted a position in the Sound Recording Department of the Metro-Goldwyn-Mayer Eastern Studios, New York City.

Charles H. Kenney, recently distribution engineer for the Brooklyn Edison Company, has joined the organization of the Rome Wire Company Division of General Cable Corporation where he will be occupied in field engineering work in the metropolitan section.

Frank Bolster, former engineer of the electrical department of the Syracuse Lighting Company, on November 1 joined the staff of Rome Wire Company Division of General Cable Corporation, as supervisory engineer. He will be located at Rome and will devote his time to engineering work in connection with the application of this company's products in the central station field.

Henry R. Stevens, formerly with Thebo, Starr & Anderton, of San Francisco, has opened a consulting engineer's office in Seattle, associated with Miles E. Clark, formerly assistant chief engineer with the Public Service Commission of the State of Washington. He will specialize in design and construction of steam and hydroelectric developments and valuation and rates of public utilities.

George S. Humphrey, formerly electrical engineer of the West Penn Power Company and Past-Chairman of the Institute's Pittsburgh Section, has been appointed chief engineer of the Light and Power Properties of The Potomac Edison and its subsidiary companies, with full charge of the generation and transmission of power in addition to the general engineering needs of the several companies. He will report direct to the president.

Matthew S. Sloan was recently elected president of the Yonkers Electric Light and Power Company, one of five companies supplying electric light and power to the Greater New York area in which he is the chief executive, the others being The New York Edison Company, the Brooklyn Edison Company, the United Electric Light and Power Company and the New York and Queens Electric Light and Power Company. These are now being operated as a system with unified management.

R. T. Pierson of New York City has been elected a director of the Bremer-Tully Mfg. Co. of Chicago, one of the pioneer companies of the radio industry. Through his early association with the Western Electric Company and later with Stromberg-Carlson of Rochester, New York, Mr. Pierson is internationally known in the telephone industry and it was through his efforts that modern telephone equipment was introduced into numerous countries of the Orient, as well as Australia, New Zealand and continental Europe.

F. V. Magalhaes, general superintendent of the Distribution and Installation Department of the New York Edison Company in Manhattan, has resigned to become vice-president of engineering of the Hall Electric Heating Company, Inc., Philadelphia. After Dec. 1 he will be located at the Philadelphia office. Mr. Magalhaes brings to this new position two years' experience with the Brooklyn Rapid Transit Company, a year's experience with the General Railway Signal Company of Rochester on design and experimental work on automatic railroad alternating-current signals and approximately twenty years in the central station field since his graduation from the electrical engineering course of the Polytechnic Institute of Brooklyn.

Clarence L. Law's appointment as Acting General Commerical Manager of The New York Edison Company has just been announced by the president, Matthew S. Sloan. Mr. Law is past-president of the Illuminating Engineering Society, a member of the Board of Governors of the Electrical Board of Trade of New York, vice-president of the New York Electrical League, and member of the American Association for the Advancement of Science. He is at present treasurer of the Illuminating Engineering Society, and an Officier de L'Instruction Publique, Republic of France.

O. Needham, formerly section engineer in charge of steel mill engineering, of the East Pittsburgh Works of the Company, has been appointed assistant superintendent, of the Testing Department, and Wm. B. Shirk will replace Mr. Needham as section engineer in charge of steel mill engineering.

Obituary

Earle N. Dillard, electrician for the Booth-Kelly Lumber Company, Springfield, Oregon and an Associate of the Institute since 1921 died as the result of a fall which he sustained from a pole on which he was changing a 2300-volt fuse for his company. His fall which was caused by an electric shock resulted in concussion of the brain and internal injuries, from which he died two hours later.

Mr. Dillard was born at Goshen, Oregon; he was but thirteen years of age when, due to the death of his father, he was called upon to support his mother and three younger brothers. Notwithstanding this unusual responsibility he finished grade school and attended the University of Oregon at Eugene, where he majored in engineering. After leaving school, he engaged with the Oregon Power Company, and in 1915 was chosen chief electrician of his present company.

S. G. Rhodes, general superintendent of the Distribution and Installation Department of the New York Edison Company since 1921 and a Fellow of the Institute (1913), died suddenly at his home in Brooklyn, N. Y., November 22, of heart disease.

Born in New York City, October 22, 1872, he was educated at Cooper Union, supplementing this schooling with private tutors. He specialized in higher mathematics under tutors from Columbia University. Entering the services of the New York Edison Company as a wireman September 1889, he worked his way up through the grades of foreman, general foreman, and others, until he reached the position which he held at his death. In 1920 he was appointed assistant to Dr. J. W. Lieb, then its vice-president and general manager, and in 1921 received his appointment as superintendent of the Distribution and Installation Department. He had charge of the transmission and distribution cable systems of Manhattan, Bronx, and Yonkers; the Meter Department, involving installation, testing and maintenance of meters in these areas; maintenance of service to customer's installations; the lighting of the city streets and parks, and the Testing Laboratories of the company. During the World War, Mr. Rhodes took active part in the preparation of specifications for electrical material and apparatus for foreign service, under the direction of the War Department. He also helped prepare plans for the lighting and protection of New York. He was the author of a number of reports and papers read before technical associations.

Among his activities in associations and clubs were membership as Fellow of the Illuminating Engineering Society; past-vice-president, director, and member of the New York Electrical Society; past-secretary, director, and member American Engineering Standards Committee; treasurer and member of the Executive Committee of the Empire State Gas and Electric Association; member, United States National Committee of the International Electrotechnical Commission, the National Electric Light Association; Association Edison Illuminating Companies, Illuminating Engineering Society of Great Britain, The Dutch Club, and The Engineers.

Lauro G. Villanueva, electrical engineer for the Calles Dam Construction, Camp No. 1, Pabellon, Ags., Mexico, was electrocuted October 2, while in performance of his duties there. Mr. Villanueva, who had only recently become an Associate of the Institute, was born at Torreon, Coah., Mexico. He received his E. E. from E. I. M. E., the Mexican college of first rank in electrical and mechanical engineering, and was afterward sent by the Mexican Bureau of Education to the Student Engineering Course of the General Electric Company; Lynn, Massachusetts. His degree of B. S. was granted him in 1925 and his work during that year consisted chiefly of experience in street lighting and river work, the testing of automotive generators and motors, assembling and testing of d-c. and a-c. motors, meter and instrument tests, and the erection and test of steam turbines and alternators. In 1926 he was transferred to the General Electric Company's service shop at Chicago, where he became experienced in maintenance and trouble shooting of electrical machinery. The following year he joined the J. G. White Engineering Company on the operation of the Calles Dam, directing the installation of generators and exciters, switchboards, the installation and connection of motors for the crushing plant, lighting of plants, etc. For the purpose of operating machinery at a Diversion Dam, six miles from the seat of the work, Mr. Villaneuva undertook the stringing of a high-tension transmission line. It was on this line that he met his death.

Adam Bosch, retired superintendent of the Newark Fire Department's Telegraph System and a Charter Member of the Institute, died at his home in Milburn, N. J., October 23. Mr. Bosch was the first head of the Fire Company's telegraph department and at the time of his retirement in 1917, had served it for forty-one years. He started with it soon after its inception and the first use of the telegraph system. He was born near Landau, Germany, in 1840, and came to this country with his parents when eleven years of age. For eighteen years he lived in New York, being educated in the public schools and at Cooper Union, where he took a five year scientific course evenings; he was graduated in 1865. At that time, he was employed in the Lock Department of the Herring Company, New York, makers of safes. In 1869 he went to Newark and started a lock business of his own with his brother Henry. In this work, Mr. Adam Bosch perfected a burglar alarm, which he patented. In 1876 he was appointed Superintendent of Telegraph for the Fire Department. For a while he continued his lock business, but subsequently gave it up to devote all interest and time to the Fire Department. Mr. Bosch was also a member of the Old Time Telegraphers and Historian Association.

William S. Hearding, who recently joined the Circuit Breaker Engineering Department of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., was killed while boarding a train October 13, 1928. He was a native of Eveleth, Minnesota, and for four years attended the Electrical Engineering course at University of Michigan, receiving his degree of Bachelor of Science in Engineering in 1925. During his senior year, he was student assistant to Professor A. H. Lovell in a course on Power Plant economics, with some experience in the running of power tests and the study of conductor size and power plant installation. Under Professor Lovell, he also redesigned the power house of the Kansas City Railway Company. In 1925 he became cadet engineer of the Brooklyn Edison Company and spent the last half of that year in the Outside Plant Bureau of Electrical Engineering Department doing work on load studies, economic size of substations, and economic size of cable for transmission feeeders and current carrying capacity under various conditions. His work prior to joining the Westinghouse Electric & Mfg. Co. was in the Electrical System Bureau of the same department doing economic studies. Mr. Hearding joined the Institute in 1926.

Frank Casper Wagner, President of the Rose Polytechnic Institute was struck by an automobile November 21 and killed. Doctor Wagner, who was born in Ann Arbor, Michigan 1864, was chosen President of the Rose Polytechnic in 1923. An academic course at the University of Michigan was followed by a course in Mechanical Engineering and the winning of an A. M. degree in 1884 and B. S. in 1885. From 1886 to 1889 he was in the employ of the Thomson-Houston Electric Company as erecting engineer, and for the last 18 months of that time had charge of all its work in the Republic of Mexico. From 1890 to 1896 he was Assistant Professor of Mechanical Engineering at the University of Michigan; Associate Professor in Steam and Electrical Engineering at Rose Polytechnic Institute from 1896 to 1904 and from that date until his election as President, was Professor of Steam Engineering and Associate Professor of Electrical Engineering there. He was administrative engineer for Indiana in the United States Fuel Administration in 1918 and the author of a book on applied electricity. Doctor Wagner joined the Institute as an Associate in 1909.

Alfred Griffin Place, consulting electrical engineer of the Youngstown Sheet & Tube Company, Youngstown, Ohio, and, since 1914, an Associate of the Institute, died October 25 at the Youngstown Hospital, following an operation. He was a native of Woburn, Massachusetts, where he attended the local high school from which he was graduated in 1904. He then entered the Massachusetts Institute of Technology and was graduated from a course in Electrical Engineering in 1908. That same year he entered the employ of the Stone and Webster Management Association in Seattle, with the Seattle Electric Company and Puget Sound Traction Light & Power Company. In September 1912 he became assistant chief electrician of the Youngstown Sheet and Tube Company, and has remained with it ever since. Mr. Place was at one time a resident of Seattle, Washington, but returned east to make his home in Boston, Massachusetts.

He was nationally known in the profession and was in charge of a force of 400 men, involving the supervision of the great variety of machinery used in the production of finished steel products including the operation and maintenance of 170 overhead cranes.

Edgar Everett Stark, Fellow of the Institute since 1913, passed away suddenly while addressing at a Rotary dinner in Poultney, Vt., on July 26th.

Mr. Stark was born in 1864 at Springfield, Ohio, and received his early education in the public schools of Cleveland. In 1886 he was graduated from Case School of Applied Science with the degree of B. S., later taking his degree of E. E. from the same school. His first years of work were spent in the employ of the Brush Electric Co., in Cleveland and New York. In 1895 he entered the service of the Stanley Electric Mfg. Co. of Pittsfield, Mass. installing their machines in various parts of California, Canada and Mexico. In 1903 he went to New Zealand and it is there that his work is best known as designer and engineer of the Waipori Falls Electric Light and Power Co. of Dunedin, New Zealand, the first long distance hydroelectric transmission in that country. In 1915 he filled the position of electrical engineer for the City of Christchurch, where he remained until returning to America in 1920. For a short time Mr. Stark was with the Cleveland Electric Illuminating Co. retiring about four years ago he took up his residence in Rockledge, Florida.

He was of a genial disposition and his sunny nature won many friends both in America and New Zealand. Mr. Stark joined the Institute in 1903.

Charles Allen Wright, a member of the Institute since 1909, died October 22, 1928, in Lakewood, Ohio.

Mr. Wright was born in Vicksburg, Mississippi, September 13, 1884. He graduated from Tulane University as Bachelor of Electrical Engineering in 1906 and the degree of E. E. was conferred *in absentia* in 1909. After a brief period in the U. S. Engineers Office at Vicksburg, and two years in the Testing Department of the General Electric Company of Schenectady, he went as instructor in electrical engineering to the Graduate School of Applied Sciences at Harvard, taking the degree of M. E. E. in 1910. The next five years were spent as telephone engineer with the American Telephone and Telegraph Company at New York. In 1915 Mr. Wright went back to teaching, serving as Professor of Electrical Engineering at Iowa State College, Ames, Ia. (1915-18); Carnegie Institute of Technology, Pittsburgh, Pa. (1918); and Ohio State University, Columbus, Ohio (1918-26). In 1926 he was called to take charge of the Radio Division of the National Carbon Company Research Laboratories at Cleveland, Ohio, a position he held to the time of his death.

Mr. Wright's chief technical interests were in the field of communication, first in telephone and then in radio. He made numerous contributions to technical literature, his book, "Telephone Communication" being published in 1925. While at Ohio State University, he was in charge of the Department of Communication and directed the work of the University radio station WEAO. He took an active part in the meetings, discussions, and committee work, of the Institute, the Institute of Radio Engineers, and the Society for the Promotion of Engineering Education. At the time of his death, he was a Reserve Officer in the Signal Corps with the rank of Captain. He was transferred from Associate to Member of the Institute last year.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Any other member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute Headquarters promptly of any changes in mailing or business address, thus relieving themselves of needless annoyance and assuring the prompt delivery of Institute mail through the accuracy of mailing records; also the elimination of unnecessary expense for postage and clerical work:

Benjamin Brown, 609-7th Ave., N. Great Falls, Mont.
Frederick R. Fowler, Box 82, Big Creek, Calif.
Dorgival G. Mororo, Rua Barao Do Triumpho 451, Brazil, South America.
Michael Salvatore, 152 N. 53rd St., Philadelphia, Pa.
S. Stangeby, Ausable Forks, N. Y.
Ralph R. Wright, 950 30th St., Oakland, Calif.
P. M. Wu, 76 N. 5th St., Newark, N. J.

A. I. E. E. Section Activities

NEW YORK SECTION TO VISIT EDISON LIGHTING INSTITUTE

On Friday, December 14, 1928 the New York Section of the Institute will hold a meeting at the Edison Lighting Institute, Harrison, N. J. The evening will be devoted to a talk on the "More Recent Developments in the Lighting Field," by A. L. Powell, manager Engineering Dept., Edison Lamp Works of G. E. Co. Mr. Powell's talk will be accompanied by novel and spectacular demonstrations, showing effects of color on surroundings, street lighting, floodlighting, etc. The meeting will be preceded by a dinner at the Edison Lighting Institute. Complete details will be given in a notice shortly to go to the Section membership.

FUTURE SECTION MEETINGS

Cleveland

Joint meeting with Cleveland Chapter, Illuminating Engineering Society. Electric League rooms, Hotel Statler. December 13.

Characteristics and Limitations of Insulating Material for Power Cables, by E. M. Davis, Ass't Chief Elec. Engr., Simplex Wire and Cable Co. Electric League rooms, Hotel Statler. January 17.

Columbus

Television, by Dirk Schregareus, Transmission Engr., Ohio Bell Telephone Co. January 4.

Aerial Photography, by Capt. A. W. Stevens, Chief Aerial Photo Branch, Wright Field. Joint Dinner Meeting with A. S. M. E. January 25.

Pittsburgh

Facsimile Picture Transmission, by Dr. Dayton Ulrey and Dr. V. Zworykin, Research Dept., Westinghouse Electric & Mfg. Co. December 11.

Our Opportunities for Service through the Institute Section, by R. F. Schuchardt, National President, A. I. E. E. Dinner meeting. January 8.

Seattle

Engineering Features of A-C. Networks, by M. T. Crawford, Supt. of Distribution, Puget Sound Power & Light Co., and W. J. McKeen, Ass't Supt., City Light Dept., City of Seattle. December 18.

Address by an Engineer of the American Telephone & Telegraph Co. January 15.

Vancouver

High-Frequency Bridge Measurements, by Dr. H. Vickers, University of British Columbia. January 8.

Washington

Principles of the Mechanical Telephone, by E. H. Goldsmith, Engr., New York Telephone Co. December 11.

Regular Meeting. January 8.

OPPORTUNITIES FOR THE YOUNGER MEMBERS IN SECTION MEETINGS

At a meeting of the St. Louis Section, September 19, 1928, C. P. Potter, Chairman of the Section, gave an address on the subject "Does the Institute Accomplish Its Object?" in which he discussed briefly the Institute activities through which the two objects stated in the Constitution are constantly being attained, and considered more fully methods by which a third object,—*i. e.*, the development of the individual engineer,—can best be attained. The substance of his remarks on this latter object is given in the following paragraphs.

The Institute keeps the individual member informed of the latest developments in the industry, provides a place where he may listen to talks on engineering subjects or take part in their discussion, and become acquainted with engineers whom he might not otherwise meet. There is no better way to to do this than by serving on Section committees, usually composed of men who have proved by consistent attendance at meetings that they are genuinely interested in Institute affairs.

At the present time most of the papers are presented by men who are recognized authorities on the subjects under consideration. Too little effort is made to induce men who are not so far advanced in the profession (especially the younger men) either to present papers or to discuss those presented by others. Many times these men feel that questions which they would like to ask might seem ridiculous or betray ignorance of a subject with which they should be acquainted. The result is that they never take part in the discussion and probably never will unless the officers of the Section plan meetings with this point in mind.

One method which might be used to get the younger engineers on their feet is to have three or four speakers in one evening, who would deal with the different phases of the same subject. For instance, at the beginning of the year one evening might be devoted to a résumé of the year's achievements in the electrical engineering field, and the general subject could be subdivided so that each of three or four men could have a perfectly definite field for his discussion. Such papers could be prepared very readily by the younger men, and would no doubt serve to draw them into the preparation and discussion of others.

Another plan which might be effective is to have a debate on some civic question with that question argued by at least two or possibly three men on each side. For instance, it might be possible to have a debate dealing with a proposed electrification of the railways entering St. Louis or the relative merits of the location of the street car tracks on Delmar Avenue between Kingshighway and Clara as compared with the arrangement ordinarily used. Various subjects of a general nature would no doubt be readily available, and the debating of such questions would be very good experience for some of our young engineers.

There certainly are men in our own Section who are thoroughly competent to present papers of real value and interest and who have never been asked to do so. These men should be called upon in preference to those from outside the Section. Papers which have been presented in the past by those who have come from a distance have been enjoyed very much, and similar papers in the future will be appreciated; but the opportunities for the development of our own local men should be kept in mind.

Each member of the Section who is requested to participated in a meeting should do so willingly and there should be free discussion of all papers. Each member should try to get the greatest possible benefit from the Section activities. The Executive Committee will welcome suggestions and constructive criticism.

SECTION ORGANIZED AT HOUSTON, TEXAS

A petition for the formation of a Section at Houston, Texas, was approved by the Board of Directors on August 7, 1928. The first meeting of the Section was held on October 17, and the following officers were elected: Claude A. Williamson, Chairman; L. K. Del Homme, Secrctary-Treasurer. At a meeting held on November 14, By-laws were adopted, and the Program Committee announced a tentative program for the year. A paper entitled *Repairs to Electrical Machinery* was presented by A. C. Kater, President, Houston Armature Works.

PAST SECTION MEETINGS

Akron

Inspection trip through the coke plant and rolling mill section of the Central Alloy Steel Company, Massillon, Ohio. October 12. Attendance 90.

Boston

Inspection trip to Ashmont Street Automatic Substation of the Boston Elevated. October 6. Attendance 125.

Cincinnati

Some Studies in Radio and Carrier Communication, by G. F. Lampkin, graduate student, University of Cincinnati. October 16. Attendance 16.

Cleveland

Union Terminal Electrification, by H. W. Pinkerton, Ass't. Elec. Engr., Cleveland Union Terminal Co. Illustrated with slides. A dinner preceded the meeting. October 18. Attendance 186.

Connecticut

Electric Welding of Steel Bridges and Buildings, by Frank P. McKibben, Consulting Engr. October 15. Attendance 81.

Dallas

The Cooperative Plan of Engineering Education, by E. H. Flath, Dean of Engg., Southern Methodist University. October 15. Attendance 42.

Detroit–Ann Arbor

Lightning Protection for Transmission Lines and Apparatus, by K. B. McEachron, Research Engr., General Electric Co. Illustrated with slides. October 23. Attendance 90.

Erie

Power Transformers and Developments of Recent Years, by F. F. Brand, General Electric Co. Illustrated with slides. October 16. Attendance 60.

Fort Wayne

The Heating of Homes by Electricity, by B. R. Green, Sales Dept., Hall Electric Heating Co., and P. S. Lyon, Chief Engr., Hall Electric Heating Corp. October 25. Attendance 50.

Houston

Organization Meeting. The following officers were elected: Chairman, C. A. Williamson; Secretary-Treasurer, L. K. Del'Homme. The meeting was preceded by a dinner. October 17. Attendance 29.

Ithaca

Some Operating Problems in Connection with Generating and Transmission Systems, by H. C. Don Carlos, Chief Operating Engr., Hydro-Electric Power Commission of Ontario. At a lecture in the morning Mr. Don Carlos addressed about 75 students on the *Economical Use of Available Water at Niagara Falls for Power Generation.* November 9. Attendance 40.

Kansas City

Engineers in Business, by W. Jack Squire, Consulting Engineer, and

Progress in the Mastery of Lightning, by F. W. Peek, Jr., General Electric Co. Slides and moving pictures were shown. October 17. Attendance 200.

Lehigh Valley

Inspection trip through the Plymouth Meeting Substation of the Philadelphia Electric Co. Joint with Engineers' Club of the Lehigh Valley. September 29. Attendance 85.

Los Angeles

System Stability As a Design Problem, by R. H. Park and E. H. Bancker, General Electric Co., and

Sphere-Gap and Point-Gap Arc-Over Voltage as Determined by Direct Measurement, by J. S. Carroll, Ass't. Professor of Elec. Engg., Stanford University, and Bradley Cozzens, Research Engr., Bureau of Power & Light. Illustrated with slides. The meeting was preceded by a dinner. October 2. Attendance 93.

Inspection trip to the new automatic mercury arc power rectifier substation of the Los Angeles Railway at Inglewood. October 6. Attendance 47.

Lynn

Motion pictures, entitled respectively "Story of Gasoline" and "Story of Lubricating Oil," were shown. October 24. Attendance 125.

The Old and the New, by L. T. Robinson, General Electric Co. This talk covered series arc lamps, small belted generators of 35-kw. capacity, the development of a-c. generators, transformers, single-phase motors, power for electric railways, and the introduction of railway motors. In conclusion Mr. Robinson outlined the principles involved in the talking moving picture and the electrical reproduction of sound from phonograph records. November 7. Attendance 150.

Madison

Banquet, after which the following talks were given: *The Obligations of the Engineer* and *What the Engineering Student May Expect after College in the Various Branches of Engineering Work.* The speakers leading the discussion were: R. F. Schuchardt, National President, A. I. E. E.; Prof. Edward Bennett, Head, Dept. of Elec. Engg., University of Wisconsin; C. B. Hayden, Principal Ass't. Engr., Wisconsin R. R. Commission; Prof. C. M. Jansky, Dept. of Elec. Engg., University of Wisconsin; T. A. Brown, Supt. of Distribution, Madison Gas and Electric Co.; H. P. S. Day, Wisconsin Telephone Co.; E. W. Odbert, Chairman, University of Wisconsin Branch, A. I. E. E., and E. A. Wegner, Student. Joint meeting with University of Wisconsin Branch. October 23. Attendance 110.

Minnesota

Electricity in Europe and America, by J. W. Lapham, Secretary, North Central Electric Association. Illustrated with slides. October 22. Attendance 40.

Pittsburgh

Railroad Electrification, by F. H. Shepard, Westinghouse Electric & Mfg. Co. Motion pictures. Joint meeting with the Electrical Section, Engineers Society of Western Pa. October 16. Attendance 106.

Rochester

Televox, by J. L. McCoy, Westinghouse Electric & Mfg. Co. Joint meeting with Rochester Engineering Society, Institute of Radio Engineers and Rochester Chamber of Commerce. October 19. Attendance 1450.

St. Louis

Fractional-Horsepower Motors, by P. W. Baker, Wagner Electric Corp. Illustrated with slides. October 17. Attendance 95.

San Francisco

System Stability as a Design Problem, by R. H. Park and C. A. Nickle, Engg. Dept., General Electric Co. September 21. Attendance 80.

Inspection trip through plant of the Pacific Electric and Mfg. Company, preceded by a dinner at which Roy Wilkins, Engr., gave an illustrated talk on "History of Oil Circuit Breakers." October 26. Attendance 205.

Schenectady

Bugs, by Dr. W. R. Whitney, Vice-President, General Electric Co. October 19. Attendance 400.

Fundamentals of Electric Distribution Practise and Economics, by D. K. Blake, Central Station Engg. Dept., General Electric Co. November 2. Attendance 150.

Professional Progress; Positive and Negative, by Alex Dow, National President, A. S. M. E., and President, Detroit Edison Co. November 9. Attendance 200.

Seattle

Some Features of Hydroelectrical Design, by A. F. Darland, Supt. of Electrical Construction, City of Tacoma. October 16. Attendance 88.

Toledo

Street Lighting, by K. M. Ried, Nela Park. Illustrated with slides. October 26. Attendance 32.

Toronto

Motor Drives for Paper Mills, by A. B. Gates, Canadian General Electric Co. October 26. Attendance 65.

Vancouver

Inspection tour of New Technical School, conducted by J. G. Lister, Principal. The meeting started with a dinner in the School Cafeteria. November 6. Attendance 37.

Washington

The Problem of Superimposed Communication Facilities, by Major C. W. Green, Bell Telephone Laboratories. A dinner preceded the meeting. October 9. Attendance 258.

A. I. E. E. Student Activities

STUDENT ACTIVITIES AT THE ATLANTA REGIONAL MEETING

The opening session of the Regional Meeting of the Southern District, held in Atlanta October 29-31 and reported more fully elsewhere in this issue, was devoted to a program prepared by the District Committee on Student Activities, including talks on the general subject Student Activities, and also some technical papers. Professor Earle S. Hannaford, Chairman of the District Committee on Student Activities, presided and C. O. Bickelhaupt, Vice-President, Southern District, gave a brief address of welcome. President Schuchardt was then introduced by Vice-President Bickelhaupt, and spoke of the fine character of the program prepared for the entire meeting, saying that he particularly liked the feature of having one session devoted to student papers. He urged that the practising engineers and students mix a great deal more at all such meetings. Chairman Hannaford introduced National Secretary F. L. Hutchinson, who stated that the Student Activities of the Institute have always been considered of great importance by the Board of Directors, and spoke briefly of the recent developments. He then introduced H. H. Henline, Assistant National Secretary, who gave a talk on the subject "Student Activities."

Chairman Hannaford announced that a cup would be awarded to the student who presented the best paper and that the decision would be made by the following judges: H. P. Charlesworth, Chairman, Meetings and Papers Committee; H. L. Wills, Chairman, Atlanta Section; and H. H. Henline, Assistant National Secretary.

During the presentation of the following program, Chairman Hannaford requested the Counselor of each Branch represented to introduce the speaker.

Student Activities, Samuel Evans, Chairman, University of Louisville Branch.

Electric Power in North Carolina, O. M. Carpenter, Chairman, North Carolina State College Branch.

Student Activities, R. S. Kersh, Chairman, A. & M. College of Mississippi Branch.

Transient Nature of Surges, Oscillations and Traveling Waves in Commercial Telephone and 110 K. V. Power Lines, Edgar R. Hauser, Alabama Polytechnic Institute.

Local Branch Constitutions and By-Laws, Their Scope and Application, Edw. M. Burn, Chairman, Georgia School of Technology Branch.

Although all the papers were well presented and contained very interesting material, the judges, after giving due weight to all the factors which they thought should be considered in arriving at a selection of the best paper, decided unanimously that the cup should be awarded to Samuel Evans, Chairman of the University of Louisville Branch, for his talk entitled "Student Activities." The cup, which was a gift of the Okonite Company of Atlanta, was presented to Mr. Evans at the opening of the General Session on Monday evening.

At a luncheon meeting of Counselors, Branch Chairmen, and others interested in Student activities, held on Tuesday, several subjects were discussed, including Section and Branch cooperation, Student Conventions in District No. 4, and delegates to District Conferences on Student Activities. President Schuchardt emphasized the great importance of the cooperation of engineers with educators and students, and said Sections and Branches that are close together are missing a tremendously fine opportunity if they do not hold joint meetings at least occasionally.

The Counselors held a business session on Wednesday morning, at which Professor W. J. Seeley, Counselor of the Duke University Branch, was elected Chairman of the District Committee on Student Activities for the year beginning August 1, 1929, and Counselor Delegate to the 1929 Summer Convention. It was decided that the next District Conference will be held at the University of Virginia during the Fall of 1929, the exact date to be determined later. It was considered desirable that each Branch make local arrangements, if possible, for sending a Junior to the District Conferences. A motion was passed expressing appreciation of the excellent work done during the past year by Professor Earle S. Hannaford as Chairman of the Committee on Student Activities.

STUDENT ACTIVITIES[1]

By Samuel Evans[2]

Enrolled Student

I. The Need of Student Activities

In the beginning when man-made schools began shaping their human output into units of definite engineering value to society, it became evident that a course in engineering, be it ever so all-encompassing, was not complete without profitable digressions from the theoretical to the practical. As this conviction became more prevalent, steps were taken to include activities in the curriculum that provided for the building of character, the development of leadership, and a pride in the chosen profession. Student activities were also formed from which it was hoped that students would absorb an antitoxin for the ills to be encountered in their own industrial careers. Men have found that the burdens of actual life fit with admirable snugness into the impressions left by student-society responsibilities.

The benefits to be derived from student activities are manifold and far-reaching. Dramatics teaches a student to play the part despite any variance of the sentiment of the play with that of the player. Stage work entails the death of stage fright, a nonchalant inurement to the criticism of lookers, and an unaffected simplicity of expression that proves invaluable to an ingenious business man.

1. An abridgment of a paper presented at the Student Activities Session of the Regional Meeting of the Southern District, held in Atlanta, October 29-31, 1928, for which the author was awarded the cup offered for the best paper.

2. Chairman, University of Louisville Branch.

Athletics teaches the necessity of unity in concerted action, a spirit of fairness and tolerance towards one's adversaries, and a whole-hearted loyalty to a cause.

Art teaches a love of the beautiful, an appreciation of a worthy technique and an eye trained in the appraisal of proportion. A man who lacks the sedative influence of a love of beauty or with no sense of proportion will not attain success because of his lack of an ideal and his inability to evaluate.

II. Three Reasons for Student Activities in the Electrical Engineering Profession

There are three main reasons for having student activities in connection with the electrical engineering profession. These are: first, professional association; second, instructive observation; and third, individual development. A man's association has a great influence upon his actions, his speech, and even his mode of mental attack. It aids him in the acquisition of what might be called a professional attitude. It also leads to the growth of a respect for the chosen profession.

A similar interest should be taken in instructive observation and individual development. A student in his scholastic work needs mental pictures of engineering objects about which the problems which he has to solve are constructed. These mental pictures taken from retinal negatives, act as drying-racks for fresh theoretical ideas. Many schools of today are including in their curricula, methods for giving the student the retinal negatives from which the mental pictures are made permitting the student to enjoy alternate periods of study and observation.

Of the three reasons for having student activities, the third is perhaps the best. A young man who expects to take the lead professionally, socially, and economically, must form habits of mind, and develop fixed traits of character and definite methods of execution. He must learn to grasp a situation with ease and think rapidly in a technical manner, checking results where possible, still being able to discuss or explain in non-technical terms to a person of lesser technical knowledge his conclusions and his methods of arriving at them.

III. Student Activities at the University of Louisville

It might be well here to give some idea of what the students of the Speed Scientific School of the University of Louisville have been doing since the organization of its Student Branch of the A. I. E. E. about a year ago, and what it intends doing in the future. It began by having one night meeting every month to which outside speakers were invited, including moving pictures, slides, and other types of illustrations. Later the executive committee deemed it necessary to have afternoon meetings as well. At these meetings papers prepared by the students were presented. Twice the Student Branch was invited to attend the local Section meetings, and upon one of these occasions, made inspection trips through the Waterside Plant of the Louisville Gas and Electric Company. Programs, in the future will consist of subjects taken from the three branches of power,—generation, transmission, and distribution. It was decided at this meeting also to take inspection trips to such places of engineering interest as the Dix River Power Plant of the Kentucky Utilities Company, the James Clark Electric Manufacturing Company, etc.

In the Speed Scientific School, there are four societies in active operation. They are the Speed Scientific Society, the Student Branch of the A. S. M. E., the Chemical Engineering Society, and the Student Branch of the A. I. E. E. Due to the fact that members of some of these socieites are also members of the other organizations, a Society Governing Board was established to have jurisdiction over the meetings of the socieites. This board is composed of the chairman of each society and the chairman of the program committee of each. The societies of the Speed School look forward to a very prosperous year under the present plan of operation. The societies have decided to take the longer trips of observation together so as to cut-down the expense per head by increasing the number of heads.

BRANCH MEETINGS

Municipal University of Akron

Experiences with Motors, by Mr. Hartman;

A Visit to a Power Station at Niagara Falls, by Mr. Tinley, and

Demonstration of the Schaefer Prone Pressure Method of Resuscitation, by P. W. Bierman and L. T. Rang, Students. Reports of Treasurer, Chairman of Membership Committee, and Chairman, Meetings and Papers Committee. October 11. Attendance 21.

Alabama Polytechnic Institute

What is Expected of the Young Engineer, by J. R. Alexander. Announcements regarding Atlanta Regional Meeting. October 11. Attendance 35.

The Vitaphone, by E. R. Jones, Student;

The Generating Equipment at the Hell Gate Station, by W. L. Cochran, Student;

Manufacture of Brick, by T. G. Barineau, Student, and

Experiences with Arc Welding, by E. Walters. J. J. O'Rourke was elected reporter to the "Auburn Engineer." October 18. Attendance 49.

Supervisory Control, by Mr. Sharit, Alabama Power Co.;

The Operation of an Ice Plant, by O. W. Baird, Student;

High-Tension Lines from the Conowingo Plant, by O. T. Allen, Student, and

The Problem Confronted with Line Surges, by E. R. Hauser. October 25. Attendance 38.

Monoplane Construction, by C. C. Pierce, Student, and

Summer Experience with a Line Construction Gang, by H. T. Drane, Student. W. P. Smith, Chairman, gave a report upon the Regional Meeting in Atlanta. H. T. Drane was elected Plainsman Reporter. November 1. Attendance 41.

University of Arizona

Business Meeting. September 29. Attendance 9.

Report on Summer and Pacific Coast Conventions, by Prof. J. C. Clark, Counselor, and

Report on Pacific Coast Convention, by Jack Hopper, Chairman. October 3. Attendance 10.

Armature Winding, by Gene Magee, Student. October 10. Attendance 10.

Moving Pictures. October 17. Attendance 8.

Railway Electrification, by H. Soliday, Student. Moving pictures on same. October 24. Attendance 10.

Hyperbolic Angles, by Geo. Linn, student. October 31. Attendance 10.

Motion picture, entitled "The Single Ridge," was shown. November 7. Attendance 14.

University of Arkansas

A, B, and C Amplifiers, by Mr. Barton, Student. October 25. Attendance 13.

Three-Phase 110-220 Metering, by B. H. Dorman, Student, and

The Levee Work on the Mississippi River, by T. L. Peters, Student. November 9. Attendance 8.

Armour Institute of Technology

The Technical Man in Industry, by Fred Schmidt, Personnel Dept., Western Electric Co. October 15. Attendance 105.

The Vitaphone and Movietone, by Robert Burns, Technician with Warner Bros. Slides and exhibits. October 29. Attendance 110.

Brooklyn Polytechnic Institute

College Education as You Get It, and What You Will Do with It, by Dean A. A. Potter of the Schools of Engineering at Purdue University, and

Review of the History of the Engineering Societies of America, by Ernest Hartford, Assistant Secretary, A. S. M. E. Third annual joint meeting, Branches A. I. E. E., A. S. M. E., A. S. C. E. and A. I. Ch. E. October 5. Attendance 75.

Bucknell University

Illuminating Engineering, by R. M. Swetland, '23, General Electric Co. Refreshments served. October 23. Attendance 48.

University of California

Trip to Big Creek Power Houses and the Yosemite National Park, by N. C. Clark, Student. Brief talks by Mr. Morgan and Mr. Leubcke. Prof. T. C. McFarland, Counselor, gave a short talk and distributed forms to be filled out by the men indicating their preferences of subjects and their desires to give student papers at the meetings. October 24. Attendance 43.

Carnegie Institute of Technology

History and Purpose of the A. I. E. E., by Prof. B. C. Dennison, Counselor. He also explained Student enrolment. Prof. W. R. Work, Head of the E. E. Dept., urged more active participation on the part of the students in the presentation of papers at the meetings of the Branch. Refreshments served. October 10. Attendance 46.

Case School of Applied Science

Faculty members and students spoke on experiences. Committees appointed. Dinner preceded the meeting. October 23. Attendance 30.

Catholic University of America

The President welcomed the new students, outlined the purposes and aims of the Branch, and announced plans for the year. A prize will be given at the end of the year for the best student paper. Refreshments were served. October 24. Attendance 20.

Clarkson College of Technology

Banquet and Social Meeting. October 23. Attendance 50.

Clemson College

A brief outline of the Regional Meeting held in Atlanta was given by Laird Anderson, Chairman. Reports of the different sessions were given by students who had attended as follows: Student Activities Session, J. F. Callaham; Power Development Session, R. L. Sweeny; General Session, M. A. Wackym; Communication and High Voltage Session, L. E. Marshall; Inspection Trips, W. P. West; and Dinner Dance, C. S. Lewis. Prof. S. R. Rhodes, Counselor, made a few remarks about the general nature of the meeting in Atlanta. November 8. Attendance 31.

University of Colorado

Principles of Banking, by J. H. Gibson, First National Bank of Boulder. October 31. Attendance 40.

University of Denver

Motion picture, "The Power Transformer." October 19. Attendance 28.

University of Detroit

Electric Arc Welding, by H. M. Doud, General Electric Co. Motion pictures on Automatic Arc Welding as Applied to Generators and Motors. Luncheon preceded the meeting. October 25. Attendance 47.

Duke University

Inductive Interference, by William Cranford, Chairman. Committees appointed. October 26. Attendance 22.

University of Florida

Representatives of Branch instructed to extend invitation at Atlanta that next Conference on Student Activities of District No. 4 be held in Gainesville. Discussion by Prof. J. M. Weil, Counselor, of plans for future meetings. October 8. Attendance 19.

Kansas State College

Business Meeting. Nomination of officers. Constitution and By-laws adopted. September 20, afternoon. Attendance 76.

Summer Experiences with Western Electric Company, Chicago, by R. L. Miller, Student; and

Summer Experiences with the Southwest Bell Telephone Company, Kansas City, Mo., by E. Skradski, Student. Talk by Prof. R. G. Kloeffler, Counselor, on the advantages of connection with the A. I. E. E. September 20, evening. Attendance 65.

Current Events, by Mr. Ankenman, and

Summer Experience with Western Electric Co., by Mr. Breneman. Film, "Fifty Years of Telephone Progress." Election of officers. October 4, afternoon. Attendance 75.

Current Events in the Field of Engineering, by C. E. Pickett, Student, and

Experiences with Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., by A. W. Broady, Student. Motion picture, "Fifty Years of Progress in Telephony." October 4, evening. Attendance 80.

University of Kansas

Research Work on a New Type of Radio Tube, by Norville Douglas. Dean G. C. Shaad, Counselor, gave a talk on the activities of the A. I. E. E. Election of freshmen representatives. November 1. Attendance 33.

University of Kentucky

Prof. W. E. Freeman, Counselor, gave an illustrated talk on the equipment of the all-electric ship, *California*. October 17. Attendance 41.

Film, "The Single Ridge." October 31. Attendance 40.

Lafayette College

Business Meeting. October 27. Attendance 21.

Lehigh University

Electricity in the Steel Industry, by D. M. Petty, '09, Supt., Elec. Dept., Lehigh Plant, Bethlehem Steel Co. Chairman S. R. Van Blarcom announced prize of $10 to be given for best student paper presented during the year. Distribution of copies of Branch Constitution which will be voted upon at the next meeting. Short talks by Prof. S. S. Seyfert, Acting Head, Elec. Engg. Dept., and Prof. J. L. Beaver, Counselor. October 25. Attendance 102.

Lewis Institute

Business Meeting. Leo Weinshank elected Secretary. Plans for the year discussed. October 12. Attendance 12.

Talks by A. Gaimari, Chairman, A. I. E. E. Branch, and the Chairman of the W. S. E. Branch, on advantages of enrolment in the societies. Prof. J. G. Bennett urged the students to join the engineering societies. October 26. Attendance 96.

Louisiana State University

Business Meeting. Election of officers. October 10. Attendance 15.

University of Louisville

The Scenic, Industrial and Power Phases of Niagara Falls, by Philip N. Fleck, representative of the Niagara Falls Chamber of Commerce. Slides.

The Queenstown Power Plant, by E. W. Davis, Student, and

The Conowingo Power Plant, by T. M. Davis, Student. Pictures. October 18. Attendance 25.

Ideas of Perpetual Motion, by J. F. Rinke, Student, and

Student Enrolment in the A. I. E. E., by Prof. D. C. Jackson, Jr., Counselor. October 25. Attendance 15.

University of Maine

Films, "The Busy Body" and "Making of Mazda Lamps." Committees were elected. Refreshments were served. October 25. Attendance 30.

Summer Work with the Bangor Hydro-Electric Co., by K. W. Downing, Student. Films, "Ties of Steel" and "The Kat and the Kit." November 8. Attendance 32.

Massachusetts Institute of Technology

What the Young Graduate May Expect upon His First Entrance into the Industry, by R. E. Doherty, Consulting Engr., General Electric Co. Two-reels on research work and industrial practise in the General Electric Company's plants. Dinner preceded the talk. October 19. Attendance 290.

University of Minnesota

Talks on the A. I. E. E. by Professors J. M. Bryant, Head, Dept. of Elec. Engg., and J. H. Kuhlmann, Counselor. Two reels "Queen of the Waves." Short entertainment. October 24. Attendance 90.

Mississippi A. & M. College

Electric Arc Welding, by H. F. Barksdale, Student, and

New Low-Voltage Cutout, by L. L. Stokes, Student. October 25. Attendance 15.

University of Missouri

Business Meeting. Election of officers. Appointment of Membership and Program Committees. September 24. Attendance 38.

Montana State College

Martin Fjeld, Chairman, reported on the Pacific Coast Convention. Election of members of Executive Committee. M. Pakala elected to Engineering Council. October 18. Attendance 82.

Substations Passing Out, by Stewart Gregg, Student (from A. I. E. E. JOURNAL, July 1928).

Redetermination of Values of Electrical Units, by Ronald Gary, Student. (From A. I. E. E. JOURNAL, August 1928). October 25. Attendance 74.

Future Progress in Television, by C. Perleberg, Student (From paper by Hugo Gernsback in *Radio News* for November).

Marvels of the Ultra Sound Waver, by E. Crumley, Student. (From paper by R. E. Wailes in *Science & Invention*, May 1928).

Super-Excitation of Synchronous Condensers, (From paper by D. M. Jones in A. I. E. E. JOURNAL, May 1928). November 1. Attendance 78.

Radio Movies from KDKA, by Frank Brown, Student. (From *Radio News*, November 1928).

The New Three-Power Locomotive, by James Woodrow, Student. (From *General Electric Review*, July 1928).

Coal Mining with Electricity, by Matt Pakala, Student. November 8. Attendance 79.

University of Nebraska

Talks by Lynn Anderson, John Byron, Philip Fink, Richard Reed and Herbert Spencer, Students, on summer employment. October 11. Attendance 36.

Metering, by F. C. Hush, Iowa-Nebraska Light and Power Co. Illustrated with various types of meters. November 1. Attendance 24.

Newark College of Engineering

New Code Laws, by G. Davis, Davis Electric Co. October 22. Attendance 24.

Mercury Arc Rectifiers, by H. Becker, Student, and

Marine Cable, by M. Slurzberg, Student. Committee of four students appointed to select the best student paper presented during the year. November 5. Attendance 24.

University of New Hampshire

Giving a Voice to the Movies, by J. Q. Wendell, Student. (From the *Scientific American*).

Hollow Spun Concrete, by M. S. Hodgdon, Student. October 6. Attendance 22.

College of the City of New York

Inspection trip to Diesel Power Plant, Church E. Gates & Co. October 15. Attendance 35.

Motion picture, "The Single Ridge." (Three reels). November 8. Attendance 24.

New York University

Motion picture, "Electrical Measurements." A. W. Schneider. October 8. Attendance 23.

Wire Line Terminating Equipment of Transatlantic Telephony, by E. M. Squire, Student. Film, "The Story of Steel." October 22. Attendance 20.

University of North Carolina

The Use of the Calculating Board for Determining Short-Circuit Currents in Complicated Power Networks, by R. F. Stainback, Instructor in Elec. Engg., University of North Carolina, and

Advantages of Student Enrolment in the A. I. E. E., by Prof. P. H. Daggett. Committees appointed. October 19. Attendance 19.

The Engineer in the Business World, by Prof. G. T. Schwenning, Commerce School, and

Facts on the Duke Power Company, by J. W. Holt, Jr., Student. November 1. Attendance 27.

University of North Dakota

Commercial Distribution, by Burton Oliver, Student. Plans made for the Engineer's float for Homecoming. October 18. Attendance 16.

Television, by George Charrier, Student. Film, "Gas Electric Busses." Election of a publicity reporter. November 1. Attendance 18.

Northeastern University

Recent Additions to the National Electrical Code, by Prof. W. L. Smith, Counselor. Refreshments were served. October 3. Attendance 18.

Importance of Cable to the Electrical Power Industry and Important Points in Its Manufacture, by E. W. Davis, Ass't.

Elec. Engr., Simplex Wire and Cable Co. Brief talk by Prof. W. L. Smith, Counselor. October 30. Attendance 87.

University of Notre Dame

Business Meeting. Branch meetings to be held second and fourth Mondays of every month. September 24. Attendance 63.

Initiation of new members. Refreshments were served. October 8. Attendance 73.

The Mechanical Aspects of Twin Branch—From Coal Car to Transmission Line, by R. E. Hieronymus, Engg. Dept., Twin Branch Power Plant, Mishawaka, Indiana;

The Neon Tube and Some of Its Uses, by E. E. Moyer, Senior, and

Personal Experiences as a Radio Operator on a Steamship, by E. G. Conroy, Jr. A drive to increase the local Student enrolment in A. I. E. E. inaugurated. Standing committee on the presentation of papers appointed. October 22. Attendance 60.

Ohio Northern University

Television, by H. R. Garn, Student. October 11. Attendance 31.

Vacuum Tubes, by M. C. Wooley, Student, and

Underground Distribution Systems, by G. D. Poole, Student. October 25. Attendance 28.

Three films, "Construction of the Conowingo Project," "Okonite Insulation of Wire" and "Arc Welding." November 8. Attendance 85.

Ohio State University

Prof. F. C. Caldwell, Counselor, gave a short talk outlining the Institute's activities. October 16. Attendance 40.

Recent Developments in the Application of Electricity to Industry, by G. E. Stoltz, Westinghouse Electric & Mfg. Co. W. E. Metzger, Chairman, Columbus Section, gave a brief talk. October 25. Attendance 70.

Ohio University

Film, "Conowingo." Membership campaign planned. October 2. Attendance 40.

Oklahoma A. & M. College

Film, "Power." Possibilities of securing new members discussed. October 11. Attendance 66.

Oregon State College

Chairman Harry Loggan gave a short report on the Pacific Coast Convention. Prof. F. O. McMillan, Counselor, reported on several activities of the Convention, and emphasized the desirability of having more Student Papers at the Branch meetings. Two meetings per month to be held. October 8. Attendance 31.

Engineering Development, History, and Future Possibilities of Dr. Bell's Ambition to Establish Universal Telephone Service, by A. K. Morehouse, Transmission Engr., Pacific Telephone and Telegraph Co., Portland, Ore.;

The Construction of the Prospect Plant No. 2 of the California-Oregon Power Co., by Larry Fisher, Senior. Slides.

Great Northern R. R. Electrification and Construction of the New Eight-Mile Electrified Tunnel through the Cascade Mountains, by Paul Klev., Jr., graduate student. Illustrated talk. Arnold Sundstrom, Student, gave an exhibition of ventriloquism. Refreshments. October 17. Attendance 66.

Pennsylvania State College

Summer Experiences, by the following Students: Mr. Newquist, with the Bell Telephone Co.; Mr. McArthur, with the Pennsylvania R. R. Co. (Altoona); Mr. Ireland, with the Bethlehem Steel Co., and Mr. Hallstrom, with the Westinghouse Electric & Mfg. Co. October 17. Attendance 57.

Prof. C. L. Kinsloe, Head, Dept. of Elec. Engg., related his experiences on a trip across the American continent during the past Summer. Two students gave talks on their travels in Europe. November 7. Attendance 40.

University of Pittsburgh

Personality, by J. B. Luck, Chairman;

Picture Transmission, by K. A. Taylor, Vice-Chairman, and

Telephone Transmission Losses, by J. G. Hoop, Secretary-Treasurer. October 19. Attendance 72.

Princeton University

Conowingo Transmission Line, by Prof. M. MacLaren, Counselor. W. V. Eakins, President, spoke briefly on the advantages of enrolment in the A. I. E. E. Brief talk by Prof. Willis on papers for prize contest in spring. Election of officers. October 19. Attendance 12.

Purdue University

The Electrical Engineering Profession, by Prof. C. F. Harding, Head of the School of Elec. Engg., and

The Work of the Institute, by Prof. A. N. Topping, Counslor. Refreshments were served. October 9. Attendance 120.

Oil-Engine Locomotives with Electrical Transmission, by A. I. Lipetz, Consulting Engr., American Locomotive Co. and Non-Resident Prof. of Locomotive Engg. Slides. Joint meeting A. I. E. E. and A. S. M. E. October 30. Attendance 160.

Rhode Island State College

Inspection trip to General Electric Co. Plant at Lynn, Mass. October 17. Attendance 20.

Power Development at Niagara Falls, by Arnold S. Judkins and Alton H. Coon, Students. Illustrated. October 24. Attendance 14.

Three reels, "The Single Ridge." October 31. Attendance 73.

Business Meeting. November 7. Attendance 14.

Rose Polytechnic Institute

Starting as an Engineer and Engineering Aptitudes (from paper by John Mills), given by H. A. Moench, Student;

Some Problems Confronting the Engineer of Tomorrow (from paper by C. S. Coler), given by R. C. Bailey, Student, and

Does Business Want Scholars (from paper by Walter S. Gifford), given by G. P. Brosman, Student. October 19. Attendance 35.

University of Santa Clara

What Industry Wants in College Men, by Geo. Gabel, Student. Committees appointed. October 11. Attendance 22.

University of South Carolina

W. E. Eargle, Chairman, gave a brief review of the Regional Meeting held in Atlanta. The papers by Samuel Evans, R. S. Kersh, O. M. Carpenter, E. R. Hauser and E. M. Burn were reviewed, and Student Activities were discussed in general with special emphasis on the need of Student Papers. Prof. T. F. Ball, Counselor, reviewed the addresses given at that meeting by John B. Taylor and Sergius P. Grace. November 2. Attendance 26.

University of South Dakota

Business Meeting. Arrangement of program of talks by students for remainder of semester. October 22. Attendance 9.

Stanford University

Summer Work with the Pacific Telephone and Telegraph Company, by E. P. Fisher, Student. W. G. Snyder, Secretary, reported on the Student Activities at the Seventeenth Pacific Coast Convention. R. D. Boynton told of his experiences in the General Electric Company's Test Course. Chairman N. R. Morgan outlined the aims of the Branch for the year. New bulletin board presented by 1927-1928 members unveiled. October 25. Attendance 29.

University of Vermont

The Atwater Kent Radio Company, by Glenn Aiken and Frank L. Sulloway, Students;

The U. S. Army Signal Corps School at Fort Monmount, N. J., by Kenneth H. MacGibbon, Students, and

The Bell System, by Laurence G. Cowles, Secretary. October 9. Attendance 9.

Virginia Military Institute

Conowingo Project, by H. T. McFall, Student;

Electric Railway Signals, by W. M. Wilson, Student;

Interconnection between Southeastern States, by J. W. Young, Student;

Transatlantic Telephony, by W. H. McClanhan, Student, and

Sterlington Power Project, by H. C. Couch, Student. October 8. Attendance 39.

University of Virginia

Prof. W. S. Rodman, Counselor, gave a talk on Branch constitutions and explained advantages of Student enrolment. Two reels, "White Coal," followed by refreshments. Joint meeting with Student Branch, A. S. M. E., for the motion pictures and refreshments. October 8. Attendance 40.

Washington University

Business Meeting. October 9. Attendance 35.

Aviation Instruments, by N. O. Anderson, Student, and a member of the Naval Reserve. October 23. Attendance 25.

Some Recent Developments in the Telephone Industry, by W. O Pennell, Chief Engr., Southwestern Bell Telephone Co. Slides. November 6. Attendance 25.

University of Washington

The Aims and Activities of the A. I. E. E., by G. E. Quinan, Vice-President, North West District, A. I. E. E. G. L. Hoard, Counselor, gave a brief talk. October 12. Attendance 29.

The Electrolytic Refining of Zinc, by George Zeh, Student. Ernest D. Engel elected Junior Representative on Executive Committee. October 19. Attendance 26.

The Skagit River Project, by C. W. Howard, Student. October 26. Attendance 20.

West Virginia University

First Aid to the Injured, by G. W. Pride, Student; *Economic Transmission of Electrical Power*, by W. H. Unger, Student; *Radio Television*, by W. H. Ross, Student; *Rebuilding Lightning Arresters*, by R. O. Boone, Student; *Electric Welding*, by J. I. Steele, Student; *Industrial Motor Applications*, by O. R. Allen, Student, and *The Brightness of the New Incandescent Lamp*, by J. S. Merritt, Student. October 22. Attendance 31.

Conowingo Development, by J. K. Gwinn, Student; *The Vacuum Tube*, by J. E. Winter, Student; *The Use of Carbon Brushes in Electric Railway Service*, by G. H. Hollis, Student; *The Correct Way to Make Splices in Electric Conductors*, by Ivan Vannoy, Student; *The Chelan River Electro Project*, by F. D. McGinnis and C. W. Thrall, Students; *The World's Largest Electric Lamp*, by G. C. Barnes, Student; *Speed in Street Railway Service*, by G. I. Burner, Student, and *Radio Acousitc Position Findings*, by F. H. Backus, Student. October 29. Attendance 29.

Problems of Interconnecting Electrical Power Systems, by T. R. Cooper, Student; *Bimetal: The Temperature Sentinel*, by R. H. Pell, Student; *The Pittsburgh Transformer Works*, by M. S. Diaz, Student; *A Long Span in the Transmission Line over the Cheat River*, by M. P. Hooker, Student, and *Manufacture of Radio Vacuum Tubes*, by W. S. McDaniel. November 5. Attendance 29.

University of Wisconsin

Prof. C. M. Jansky, Counselor, gave a talk on the aims and ideals of the Student Branches of the A. I. E. E. and the advantages of Student enrolment. Chairman Odbert outlined program for the year. Prof. J. R. Price gave a brief report on the Western inspection trip. Prof. Edward Bennett, Head, Dept. of Elec. Engg., gave a report on the Eastern trip. October 16. Attendance 50.

Banquet, joint with Madison Section, A. I. E. E. (Detailed report in Section Activities department of this issue). October 23. Attendance 110.

Worcester Polytechnic Institute

My Experiences with the New York Telephone Company, by E. G. Norton, Senior;

Gas Distribution, by A. W. Knight, Senior, and

The Bell Telephone Laboratories, by R. A. Beth, Instructor in Physics. October 22. Attendance 40.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES OCT. 1-31

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

AIDE-MEMOIRE DE L'INGENIEUR MECANICIEN.

By J. Izart. 5th edition. Paris, Dunod, 1928. 1263 pp., diagrs., tables, 8 x 5 in., cloth. 95 fr.

A "pocket-book" of mechanical engineering, covering the same field as our well-known American works, but presenting French practise. The popularity of the book is shown by the frequency with which new editions have been required.

The present edition has been completely revised and reset. It contains many tables and formulas of value to engineers compelled to use metric measurements in machine design.

DIE AUSBREITUNG DER ELEKTROMAGNETISCHEN WELLEN.

By Alfred Sacklowski. Ber., Weidmannsche Buchhandlung, 1928. 129 pp., 9 x 6 in., paper. 4,50 r. m.

In 1888 Hertz published his classic paper on the propagation of electric power, but it was not until 1905, when radio-telegraphy was already becoming important, that Tissot, and Duddell and Taylor undertook to test the theory by measuring fields. Since that date interest in the propagation of electric waves around the earth has increased so rapidly that many papers have appeared, scattered through many periodicals.

Dr. Sacklowski has now prepared a summary of this literature in convenient form, giving in brief compass a connected account of our present knowledge. A valuable bibliography of nearly 500 papers is given.

BEHANDLUNG VON SCHWINGUNGSAUFGABEN MIT KOMPLEXEN AMPLITUDEN UND MIT VEKTOREN.

By Hans Georg Möller. Lpz., S. Hirzel, 1928. 128 pp., illus., 9 x 6 in., paper. 6.-r. m.

The method presented in this book differs from that ordinarily taught to students of electrical engineering and physics, and is much simpler in its application to calculations involving electric waves and light waves. The text is based upon Dr. Möller's courses at Hamburg and Charlottenburg, and is written so that it can be used by engineers with only ordinary training in mathematics.

The theoretical principles of the method are described concisely. About two-thirds of the book are occupied by examples showing the application of the method to practical problems in electrical engineering.

DIE BESTIMMUNG DER DAUERFESTIGKEIT DER KNETBAREN, VEREDELBAREN LEICHTMETALLEGIERUNGEN.

By Richard Wagner. (Bericht aus dem Institut für Mechanische Technologie und Materialkunde der Technischen Hochschule zu Berlin. Heft 1). Berlin, Julius Springer, 1928. 64 pp., illus., diagrs., tables, 9 x 6 in., paper. 6.-r. m.

Describes a series of extensive tests of duralumin, electron, lautal, and other light alloys, undertaken to determine their durability when exposed to repeated shock and vibration. The results are given in detail. The conclusions drawn will be of interest to designers of automobiles, aircraft, and other structures in which light alloys are used for structural members.

BLUE BOOK OF FACTS OF MARINE ENGINEERING. Ed. 6. N. Y., Ocean Publishing Co., 1928. 135 pp., 6 x 4 in., cloth. $3.00.

This little catechism contains questions and answers for engineers preparing for marine engineers' licenses of every grade.

THE CHEAT MOUNTAIN COAL FIELD OF RANDOLPH COUNTY, W. VA.

By David B. Reger. (West Virginia Geological Survey, Bulletin 3). Morgantown, W. Va., 1928. 34 pp., tables, map. Paper, $1.00.

This Bulletin describes an entirely new field of New River Coal in eastern West Virginia, including location, topography, transportation, geology and rock structure, with table of intervals above and below the Sewell Coal, history of discovery of field, and a brief description of the coals, including estimates of tonnage for the Upper Freeport, Gilbert, Castle, Hughes Ferry, Sewell, and Fire Creek Coals; it also includes the detailed records of 16 core tests by the W. Va. Pulp & Paper Co.; a table showing the elevation and thickness of the coal at 140 mines and prospect openings shown on map; another showing analysis of 24 samples including 15 tests of fusing point of ash.

(Address: West Virginia Geological Survey, P. O. Box 879, Morgantown, W. Va.)

COLLECTED WORKS OF J. WILLARD GIBBS.

N. Y., Longmans, Green & Co., 1928. 2 v., port., tables, 9 x 6 in., cloth. $6.00 (2 v.)

Willard Gibbs is rated, by competent critics, as the greatest genius America has produced. His writings on thermodynamics, after long neglect, became the foundation of physical chemistry and established his position as one of the greatest physicists of all time.

As his writings have been out of print for some years, this new edition will be welcome to many physicists and chemists who wish to study his work at first hand. The collection is complete and includes the "Elementary principles in statistical mechanics," which was omitted in the former edition. A biographical sketch is also included.

COMPOSITION OF WATER.

By J. R. Partington, Lond., G. Bell & Sons, 1928. (Classics of Scientific Method). 106 pp., illus., 7 x 5 in., paper. 1/6.

The series to which this volume belongs aims to provide inexpensive reproductions of the great masterpieces of science in convenient form, with an account of the action and reaction of ideas which led up to the crucial experiments carried out and described by some great master.

In the volume on water Dr. Partington traces, chiefly in the words of the discoverers themselves, the experimental investigations that led to our present very exact knowledge of its composition. The researches of Cavendish, Lavoisier's work, Priestley's and Mouge's work, and the investigations of later workers, down to recent times, are given.

COURS DE MECANIQUE PROFESSE A L'ECOLE SUPERIEURE DES MINES.

By Paul Levy. Paris, Gauthier-Villars et Cie, 1928. 303 pp., diagrs., 10 x 6 in., paper. 50 fr.

Professor Levy here presents his course at the "Ecole Supérieure des Mines." The text is adapted, in length and presentation, to the ordinary needs of engineering students. It is based on classic works written from the analytical point of view but gives more than the usual attention to mechanical and geometrical considerations.

COURS D'EXPLOITATION DES MINES, v. 1.

By Haton de la Goupillière. 4th edition. Paris, Dunod, 1928. 1216 pp., illus., tables, 10 x 7 in., paper. 189 fr.

This treatise on mining is too well known to need an introduction. First published in 1885, it at once became a favorite work, and successive editions have maintained its popularity. Volume one of the fourth edition has now been printed, and three other volumes will appear later.

This new edition has been revised and so considerably extended by J. de Berc that an additional volume is necessary. The revision has eliminated obsolete matter and brought the text abreast of current practise.

COURSE IN ELECTRICAL ENGINEERING, v 2; Alternating Currents.

By Chester L. Dawes. Ed. 2, N. Y., McGraw-Hill Book Co., 1928. 618 pp., illus., diagrs., 8 x 6 in., cloth. $4.00.

Although this book was prepared for semi-elementary courses in alternating currents, such as are given to non-electrical students of engineering, it has won wide acceptance as a text for courses in electrical engineering. This widened field of use, as well as the changes and progress of the last six years, have been taken into account in the revision of the work. A chapter on complex quantities has been added, and their application to polyphase systems is presented. A new chapter discusses the principles and simplex uses of electron tubes. Throughout the book late developments in a-c. apparatus and methods have been included. The book is an excellent introductory text, preparing the student for more advanced works.

ENGINEERING EDUCATION; Essays for English.

Selected and edited by Ray Palmer Baker. 2d edition. N. Y., John Wiley & Sons, 1928. 233 pp., 8 x 5 in., cloth. $2.00.

This collection of essays by noted engineers and scientists discusses the origins and types of engineering education and the place in engineering of the basic sciences. The book is intended primarily to provide students of engineering with good models of exposition, as part of their training in language. At the same time, the collection presents an ideal of education which will not only be of value to the student, but will also be of interest to all who are interested in the trend of present thought upon this topic.

ENGINES.

By E. N. Da C. Andrade. N. Y., Harcourt, Brace & Co., 1928. 267 pp., illus., 8 x 6 in., cloth. $3.00.

An interesting description of the chief kinds of engines by which the heat of burning fuel is turned into work, and of the scientific principles upon which their action depends. The book is based upon the author's Christmas Lectures at the Royal Institution of Great Britain; hence is intended for readers without scientific knowledge. The author writes in interesting fashion, yet with scientific accuracy. The illustrations are unusually good.

DIE ENTROPIE-DIAGRAMME DER VERBRENNUNGSMOTOREN.

By P. Ostertag. 2d edition. Berlin, Julius Springer, 1928. 78 pp., diagrs., tables, 9 x 6 in., paper. 4,50 r. m.

The new edition of this work on the entropy diagrams of internal combustion engines shows no fundamental changes, but the text has been revised and extended wherever necessary.

The basic conceptions on the behavior of gas mixtures and on combustion set forth in part one are used, in part two, to show how the behavior under various conditions of piston gas engines may be predetermined. The use of the gas entropy table in design is shown.

The third section discusses the design of gas turbines, with particular attention to the author's solution of this problem. The last section treats of some special problems.

DIE ENTWICKLUNG DES DEUTSCHEN BERGBAUES.

By A. Schwemann. Ber., V. D. I. Verlag, 1928. (Deutsches Museum Abhandlungen und Berichte). 20 pp., illus., 8 x 6 in., paper. 1.-r. m.

A popularly written sketch of the development of mining in Germany from the earliest times to the present. The pamphlet is intended especially for visitors to the mining exhibit in the Deutsches Museum and is illustrated by photographs of some of the important exhibits.

DAS FORDERHOHENVERHALTNIS DER KREISELPUMPEN FUR DIE IDEALE UND WIRKLICHE FLUSSIGKEIT.

By Wilhelm Schulz. (Forschungsarbeiten, heft 307). V. D. I Verlag, 1928. 28 pp., diagrs., tables, 11 x 9 in., paper. 5.-r. m.

In the first portion of this research the author investigates mathematically the flow of an ideal fluid in radial-discharge centrifugal pumps. The theoretical delivery and the conditions of delivery are calculated, and numerical values are found for all possible combinations of number of blades, blade angle and wheel proportions. These theoretical results are then compared with those obtained from a commercial pump in which various numbers of blades and various blade angles could be obtained.

New data were obtained upon maximum efficiency, special throttle-head curves, favorable numbers of blades and deliveries, cavitation and other properties. The actual and theoretical results are compared and methods of approximation studied critically.

FRACHTVERHALTNISSE UND FRACHTLAGE DER AMERIKANISCHEN EISENINDUSTRIE.

By Fritz von Haniel. Berlin, V. D. I. Verlag. 1928. 62 pp., diagrs., 8 x 6 in., paper. 4.-r. m.

An economic study of transportation conditions in the American iron industry, based on first hand study. Shipping facilities, tariffs, and other matters affecting freight rates for ore, coal, and finished products are discussed.

GRUNDPLAN DER WISSENSCHAFTLICHEN BETRIEBSFUHRUNG IM BERGBAU.

By Kurt Sieben. Berlin, V. D. I. Verlag, 1928. 148 pp., diagrs., forms, 8 x 6 in., paper. 10,50 r. m.

Attempts to present the outlines of a plan for the scientifimanagement of mining operations. The author has not atc tempted to present a system in complete detail, but rather to call attention to the principles involved, and to suggest ways in which they can be effectively applied in mines.

HERBERT HOOVER; a reminiscent biography.

By Will Irwin. N. Y., Century Co., 1928. 315 pp., illus., ports., 8 x 5 in., cloth. $3.00.

This biography by a college mate and lifelong friend gives an accurate, if eulogistic account of Hoover's life and work. The story is told in interesting fashion, with emphasis upon the adventures of Hoover's career.

JAHRBUCH DER BRENNKRAFTTECHNISCHEN GESELLSCHAFT, v. 8, 1927.

Halle (Saale), Wilhelm Knapp, 1928. 50 pp., illus., 11 x 8 in., paper. 4,60 r. m.

This yearbook contains the proceedings of the tenth annual meeting of the Society and the four papers presented at that time. These are: "International petroleum politics," by Dr. Tetsche; "Transportation fuels, their provision and the economic importance of increased pressure in the engine," by W. Ostwald; "Air traffic and its demands upon the fuel supply," by H. von Williamowitz-Moellendorff; and the "Position of the German coal industry upon the supply of fuels for transportation," by Dr. Faber.

LEHRBUCH DER PHYSIKALISCHEN CHEMIE, v. 2, pt. 3.

By Karl Jellinek. 2d edition. Stuttgart, Ferdinand Enke, 1928. Illus., diagrs., tables, 10 x 7 in., paper. 32.-mk. v. 2 complete, unbound, 88.-mk.; bound 92.-mk.

This work will undoubtedly remain for years one of the most important treatises on physical chemistry. Dr. Jellinek discusses the subject theoretically, as well as experimentally, in a clear, readable style, with a wealth of detail. Many illustrations accompany the text and there is a wealth of references to the literature. The book is useful both as a textbook for advanced students, and as a reference work.

LUDWIG FRANZIUS.

By G. de Thierry. Ber., V. D. I. Verlag, 1928. (Deutsches Museum Abhandlungen und Berichte). 33 pp., port., 8 x 6 in., paper. 1.-r. m.

A brief biography and appreciation of the noted hydraulic engineer, based upon his autobiography. The brochure is one of a series issued by the Verein Deutscher Ingenieure and the Deutsches Museum, to illustrate the development of special branches of engineering through the labors of pioneer workers.

MARINE DIESEL OIL ENGINES; a manual of marine oil engine practice.

By J. W. M. Sothern. Ed. 3. Lond., Crosby Lockwood & Son, 1928. 949 pp., illus., plates, diagrs., 9 x 6 in., cloth. 45 s.

A practical treatise on the principles, construction and running of these engines. The work is designed as a text-book for engineers preparing for the British Board of Trade examinations for licenses and treats the subject in great detail, although elementary in character. Much space is given to the details of the various makes of engines and to practical operation, repair and maintenance.

MATERIALPRUFUNG MIT RONTGENSTRAHLEN.

By Richard Glocker. Berlin, Julius Springer, 1927. 377 pp., illus., tables, 9 x 6 in., cloth. 31,50 r. m.

Intended as a general introductory text which will provide the beginner with enough knowledge to enable him to test materials in this way. The book opens with a brief accoun of thet physical principles involved, but the greater part of the book is devoted to methods, which are illustrated by practical examples. A large number of useful tables are included and there is a useful bibliography.

METHODEN DER PRAKTISCHEN ANALYSIS.

By Fr. A. Willers. Ber. u. Lpz., Walter de Gruyter & Co., 1928. 344 pp., diagrs., tables, 9 x 6 in., paper. 20.-r. m.

An introduction to the methods of practical analysis, including numerical, graphic, and instrumental methods. Special attention is paid to the accuracy obtainable by the various methods. Numerous examples show the practical application of the methods.

OIL ENGINE POWER PLANT HANDBOOK.

Edited by Julius Kuttner. Ed. 4. N. Y., National Trade Journals, Inc., 1928. 288 pp., illus., 11 x 8 in., cloth. $5.00.

The Handbook contains a number of articles by various experts upon practical problems connected with oil and Diesel engine plants. Operation and maintenance, efficiency standards, electrical layouts for central stations, switchgear, piston ring action, cooling water systems, lubricants, exhaust heat recovery, and other live topics are discussed in a practical manner. In addition, the Handbook contains descriptive data, prepared by the manufacturer, upon most of the oil engines produced and sold in this country.

PRACTICAL INDUSTRIAL FURNACE DESIGN.

By Matthew H. Mawhinney. N. Y., John Wiley & Sons, 1928. 318 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.00.

A discussion of practical methods for solving the problems and difficulties most frequently met in selecting, designing, and operating industrial heating furnaces as distinguished from melting furnaces. The methods presented have been used successfully by the author and are presented as a contribution to a subject that is not as yet thoroughly understood.

Among the topics are the selection of fuels, the application of the heat, methods of handling material, heat economy, the design of refractories and metal parts of furnaces and temperature measurement and control.

RESISTANCE DES FONDS BOMBES.

By E. Hoehn. Paris, Ch. Béranger, 1928. 86 pp., diagrs., tables, 9 x 6 in., paper. 20 fr.

The increasing frequency of failures of the dished heads of cylindrical pressure vessels led the Swiss Society of Steam Boiler Proprietors to inaugurate investigations of the matter some years ago. In 1923 a report on the strength of electrically welded vessels was printed, which is now followed by this furth er contribution.

This pamphlet discusses theoretically the theoretical aspects of the strength of dished heads in pressure vessels, describes the tests made by the author and gives the conclusions derived from the work.

DIE TECHNIK ELEKTRISCHER MESSGERATE, v. 1.

By Georg Keinath. 3rd edition. München & Berlin, R. Oldenbourg, 1928. 612 pp., illus., 10 x 7 in., cloth. 35.-r. m.

This work is intended as a reference book for the engineer who must use electrical measuring instruments. It aims to present the useful information without many formulas but with enough description of the various types and designs and of their fields of usefulness, to assist in the selection and use of suitable equipment. Electric meters and pyrometers are omitted, as well as instruments intended especially for laboratory use.

The book is expanded to two volumes in this edition. The first volume discusses the general properties of these instruments, the materials of construction, the various instruments on the market and their accessories.

TIMBERING OF METALLIFEROUS MINES.

By J. F. Downey. Lond., Charles Griffin & Co., 1928. 258 pp., illus., 9 x 6 in., cloth. 25 s.

This treatise by the New Zealand Government Inspector of Mines is intended to provide the practical miner with a reasonably comprehensive handbook on mine timbering. The author has collated the information scattered through mining literature, and has filled the gaps and supplemented the information by drawing upon his own experience, so that the book covers in a

practical way the methods of which knowledge is essential to the miner.

UBER DIE SCHMIERSCHICHT IN GLEITLAGERN UND IHRE MESSUNG DURCH INTERFERENZ.

By Robert Wolff. (Forschungsarbeiten, heft 308) Berlin, V. D. I. Verlag, 1928. 25 pp., diagrs., tables, 12 x 9 in., paper. 5.-r. m.

Presents the results of investigations carried out in the bearings laboratory of the German railways upon conditions in heavily loaded bearings. The author describes a new method of measuring oil films which is particularly accurate for bearings of this kind and presents some conclusions drawn from measurements made by it. Among other results, he shows that viscosity is entirely unreliable as an indication of lubricating value, and that the classic hydrodynamic ideas concerning the thickness of oil films are inadequate for thin films.

DIE VERWENDBARKEIT DER RONTGENVERFAHREN IN DER TECHNIK.

By C. Kantner and A. Herr. Ber., V. D. I. Verlag, 1928. 77 pp., illus., 8 x 6 in., paper. 4,50 r. m.

The increasing use of X-rays in testing materials is the cause of this little book, which is intended for those interested in inspection who are not versed in X-ray photography.

The treatment is entirely practical. The authors point out the fields in which the method has been found useful and describe the apparatus used. Directions for equipping a laboratory are given, and there is a brief bibliography.

WARME-UND KALTEVERLUSTE ISOLIERTER ROHRLEITUNGEN UND WANDE.

By Grunzweig and Hartmann, G. M. B. H. Ludwigshafen a' Rhein. Berlin, Julius Springer, 1928. 269 pp., 9 x 6 in., fabrikoid. 16.-r. m.

This collection of tables has been prepared by a manufactory of heat-insulating materials for use in its own work. The tables show in detail the hourly loss of heat or cold from pipes and chambers, the effect of wind, and give other useful data. They are calculated for all ordinary commercial sizes of pipe and for temperatures from − 40 cent. to 1000 cent. and can be used for pipes with any or no insulation.

WIRKUNGSWEISE ELEKTRISCHER MASCHINEN.

By Milan Widmar. Berlin, Julius Springer, 1928. 223 pp., diagrs., 9 x 6 in., paper. 12.-r. m.

Dr. Vidmar's work is written to meet the needs of students who need a concise survey of the theory of electrical machines, and of electrical engineers who need to know what occurs in electrical machines, although not engaged in their design or construction. For these readers he presents the theory with emphasis upon the physical picture of the machine at work and without attention to design or structural details.

Starting with the point of view that there is actually only one electrical machine, Dr. Vidmar discusses first its simplest form, the transformer. He then discusses successively mechanical transformation, synchronous machines, asynchronous machines and collector machines.

ZUR THEORIE DES FERNSPRECHVERKEHRS.

By K. Frei. Berlin, Weidmannsche Buchhandlung, 1927. 138 pp., 9 x 6 in., paper. 4,50 r. m.

This introduction to the theory of telephone traffic is intended primarily for those who are somewhat distrustful of it, because it is so completely based on probabilities. It aims to explain the theory and show its main conclusions sufficiently to prepare the reader for a complete understanding of current writings on the subject, and to enable him to pass judgment on the results.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contributions from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.

1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.

57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

MEN AVAILABLE

GRADUATE ELECTRICAL ENGINEER, 24, married, B. S. in E. E., 1927. Desires position with public utility or industrial concern. One year's experience in power plant work. Now employed; available at reasonable notice. Location preferred, East. C-5179.

GRADUATE ELECTRICAL AND MECHANICAL ENGINEER, 25, married. 5 years' experience as plant engineer and designer, construction and operation of power plants. Desires a position with a public utility or manufacturing concern. Location and salary secondary to opportunity. C-5183.

GRADUATE ENGINEER, 24, single, B. S. in E. E., State College of Washington, 1928, desires employment with manufacturing or public utility in application, design, or manufacturing fields. Location, immaterial. C-5115.

GRADUATE ELECTRICAL ENGINEER, 28, single; 2½ years' experience in General Electric Student Engineering Department; 6 months with public utilities. Desires connection with public utility or manufacturing concern. Also willing to accept a position in Europe or South America. C-3762.

JUNIOR ELECTRICAL ENGINEER, S B., 1927. One year shop course in industrial plant (three months layout and machining, three months fabricating, including electric and oxy-acetylene welding; six months test of Diesel-electric installations). Wishes to change to a growing company where there will be opportunity for advancement. C-5165.

GRADUATE ELECTRICAL ENGINEER, 29, married. One year G. E. Test Course. One year as instructor in electrical engineering. Five year's diversified electric utility experience as switchboard operator, maintenance man, test engineer and assistant electrical engineer on substation construction. C-5186.

ELECTRICAL-MECHANICAL ENGINEER, 31, married, desires responsible position with industrial or public utility. Four years electrical maintenance, steel mills; one year G. E. Test; two and a half years designing draftsman, public utility; one-half year electrical instructor, trade school and one year assistant electrical engineer, industrial operating own hydro plants. Location, immaterial. C-2902.

RECENT GRADUATE, S. B. in E. E., M. I. T., 1927, 22, single, desires position in commercial field. One year's experience as instructor in large Western University. Can furnish excellent references. Location preferred, East. C-3550.

ELECTRICAL ENGINEER, 28, graduate 1924, good personality, four years' experience as follows: two years electric lighting and power layout for factories and buildings; two years electric traction work, layout, estimating and construction of overhead and underground feeders. Good

draftsman, able to handle men. Location preferred, New York or vicinity. B-6384.

GRADUATE ELECTRICAL ENGINEER, single, 26. One year on Westinghouse Student Course. Three years' experience in general electrical engineering work, miscellaneous applications. Would like position in office of consulting engineer or as assistant to electrical engineer of large industrial plant or group of plants. Location preferred, East or Middle West. C-5207.

GENERAL OR WORKS MANAGER. At present holding position as works manager in plant employing three hundred hands manufacturing electrical power apparatus; alternating- and direct-current motors and generators, transformers, switchboards, control apparatus. American, healthy, active and qualified by education, experience and ability to discharge the duties of general manager. Location, immaterial. C-4206.

POWER AND WORKS ENGINEER, with 15 years' experience in large industrial plants, desires location in Southern territory. Wide experience in all classes of industrial plant power and engineering work including design, construction of generating, refrigeration plants. Familiar with rayon and other chemical plant equipment, processes. University graduate, married, settled. Possesses initiative, analytical powers. B-5326.

ELECTRICAL ENGINEER desires position doing research or development work. Thoroughly trained and competent meter engineer. Experienced in combustion and general laboratory and power plant testing. Have been successful along development lines. Also, extensive public utility experience. C-5258.

ELECTRICAL ENGINEER, 1923 graduate, two years' experience in abstracting and translating technical articles and three years of research work on electric interference. Familiar with audio-frequency measurements. Analytically inclined. Good references. B-7091.

ELECTRICAL ENGINEER, married, 30, best of references. Seven years' distribution and operating experience desires connection as distribution or plant engineer with operating company in south or southwest. C-4734.

GRADUATE ELECTRICAL ENGINEER, 30, married. One and one-half years telephone engineering. Four years with general contractor on building construction. Can handle men. Desires responsible position with future. C-5298.

ELECTRICAL ENGINEER, 29, married. Wide experience in the design, construction and operation of power stations and substations. Successful record in development of economic designs and in handling engineering organization. B-7809.

MECHANICAL ENGINEER, 28, single, graduate Polytechnic of Milan (Italy); also American college education, 5 years' experience in U. S. A. in electrical testing, drafting, etc. Reasonable salary. Available immediately. Location, New York City. C-4246.

ELECTRICAL ENGINEER, 23, single. Graduate E. E. 1926, desires a position with a power company; 1½ years General Electric Test; some drafting experience. Location preferred, California. C-5259-89-C-S.

PLANT ENGINEER; graduate Massachusetts Institute of Technology, American descent. Over 20 years' experience in design, construction, maintenance of factory buildings, power plants, etc. Have reorganized non-productive departments with large savings and reconstructed buildings with stopping operation. Registered Mechanical Engineer, New Jersey, Pennsylvania. Excellent references. Available at once. B-5714.

ELECTRICAL ENGINEER, German, I. C. S. graduate, 38, married, American citizen, desires position with electrical concern; expects to work up. Rochester, N. Y. or vicinity preferred. Available on two weeks' notice. C-5264.

RECENT GRADUATE, B. S. in E. E., 25, single, desires position where knowledge of radio will be of value. Now employed by State Highway Department, but available on short notice. Can furnish excellent references as to character and ability. Location preferred, South or Middlewest. C-5265.

ENGINEER, 41, married, is open for position as estimating, production or sales engineer, having 20 years' experience with leading manufacturer, with thorough knowledge of modern factory methods, and thoroughly familiar with office and factory systematizing. Would go to any part of the United States or to European countries. C-5231.

SALES EXECUTIVE, 40, graduate electrical engineer with commercial school training, Westinghouse apprenticeship, eight years factory and construction experience, nine years very successful sales and executive experience in mechanical and electrical lines. Pleasing personality, good organizer, able to handle men. Extensively traveled, well read, speaks Spanish and French. B-3065.

ELECTRICAL ENGINEER, 30, married. Technical University graduate. Practical experience as mechanic, electrician and armature winder. Has been draftsman on telephone apparatus, small motors and other electrical appliances. For the last three years draftsman and checker on electrical power stations and outdoor switch yards. Location preferred, East or Europe. B-9786.

ESTABLISHED CONSULTING ENGINEER in large eastern city, specializing in reports, valuations and statistics used by utilities, commissions, engineers, and operating and management companies throughout the United States, desires to form connection with large organization where both engineering services and facilities for securing engineering business could be used advantageously. B-7006.

ELECTRICAL ENGINEER, University graduate, 34, married; 9 years' experience in electric and Diesel-electric traction field here and abroad, desires position with well established company. Very well acquainted with latest developments in Diesel-electric traction vehicles. Now engaged. C-5268.

GRADUATE ELECTRICAL ENGINEER, 36, married; 13 years' experience covering designing, construction, maintenance of distribution and transmission systems, out door transformer substations, generating stations; two years efficiency and research engineer for coal mine; three years designing and operating coal cleaning plants, using pneumatic separators. Desires connection with public utility, large coal company. C-5277.

GRADUATE ELECTRICAL ENGINEER, 24, single, desires position in application or design of small motors. One year on Westinghouse Student Course; six months in Westinghouse Design School; one and one-half years on design and construction of small motors. Available on short notice. Location, United States, east preferred. C-5051.

CATENARY ENGINEER, graduate, B. S. and C. E., American, 48, married; twenty years' experience in general engineering electrical traction work; specialized experience in overhead contact systems, designing, estimating, constructing, developing, selling, consulting; transmission line design; special experience in railway electrification, manufacture, installation, project work, reports; railway valuation. Now available. C-5262.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR TRANSFER

At its meeting held November 8, 1928, the Board of Examiners recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

KURTZ, EDWIN, Prof. and Head Elec. Engg. Dept. and Acting Dean of Engg. School, Oklahoma A. & M. College, Stillwater, Okla.
NELSON, ARTHUR LINDSAY, Partner in firm of Jackson & Moreland, Boston, Mass

To Grade of Member

ANDERSON, BURTON E., Electrical Engineer, Guayama, Porto Rico.
BLYE, PAUL W., Engineer, American Tel. & Tel. Co., New York, N. Y.
BOISEN, ROBERT L., Electrical Engineer, Lake Superior Dist. Pr. Co. and Michigan Gas & Elec. Co., Ashland, Wis.
BROOME, GEORGE W., Asst. Engr., Columbia Engg. and Mgt. Corp., Cincinnati, Ohio.
BURNAP, ROBERT S., Engineer in charge of Testing Section, Edison Lamp Works of General Elec. Co., Harrison, N. J.
CALKINS, GEORGE H., Manager, General Elec. Co., Buffalo, N. Y.
CORRELL, JAMES A., Prof. of Elec. Engg., University of Texas, Austin, Texas.
DODSON, RALPH E., Accoustical and Insulation Engineer, Cincinnati, Ohio.
FLAHERTY, BENJAMIN G., Elec. Engr., Puget Sound Bridge & Dredging Co., Seattle, Wash.
FLEISCHMANN, EDWIN, Industrial Heating Engr., Niagara Falls Power Co., Niagara Falls, N. Y.
GOODERHAM, JOHN W., Telephone Engineer, Bell Telephone Labs., New York, N. Y.
KIERSTEAD, FRIEND H., Electrical Engineer, General Elec. Co., Pittsfield, Mass.
NORTH, JOHN R., Asst. Investigations Engineer, Commonwealth Power Corp. of Michigan, Jackson, Michigan.
PEASE, EDWARD I., Associate Engineer, U. S. Engineer Dept., Seattle, Wash.
SAWYER, R. TOM, Oil and Gas Elec. Rwy, Equipment Engr., General Elec. Co., Erie, Pa.
SCHIRMER, AUGUST H., Telephone Engr., American Tel. & Tel. Co., New York, N. Y.
SMITH, CLIFTON E., Consulting Elec. Engg., 116 West 39th St., New York, N. Y.
SPRATLEY, JAMES B., Telephone Engr., Chesapeake & Potomac Telephone Co., Washington, D. C.
THIMME, EDMUND J., Division Engineer, Public Service Elec. & Gas Co., Paterson, N. J.
WALTER, OTTO W., Engr., Hall Electric Heating Co., Fort Wayne, Indiana.
WEBER, HOWARD H., Asst. Engr., Rome Wire Co., Rome, N. Y.
WHITE, THOMAS C., Elec. Supt., State Line Generating Co., Chicago, Ill.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the Applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before December 31, 1928.

Adams, O. R., American Tel. & Tel. Co., New York, N. Y.
Amoo, L. R., Radio Salesman, Morristown, So. Dak.

Annett, R., Puget Sound Power & Light Co., Everett, Wash.
Arnold, H. O., Federal Shipbuilding & Drydock Co., Kearny, N. J.
Baker, H. A., (Member), John Tarleton A. & M. College, Stephenville, Texas
Balkow, C., Washington Water Power Co., Spokane, Wash.
Barry, J. E., Jr., Niagara Electric Service Corp., Niagara Falls N. Y.
Battistini, L. G., New York Edison Co., New York, N. Y.
Bell, E., Pennsylvania Power & Light Co., Hazleton, Pa.
Belt, W. B., Becker Moore & Co., Inc., N. Tonawanda, N. Y.
Berkner, L. V., Bureau of Standards, Washington, D. C.
Bigelow, P. W., 110 West 78th St., New York, N Y.
Bohan, P. C., American Tel. & Tel. Co., New York, N. Y.
Bredehoft, H. A., Bell Tel. Laboratories, Inc., New York, N. Y.
Bricker, L. B., Southwestern Bell Tel. Co., Houston, Texas
Brouwers, P. W., New England Tel. & Tel. Co., Boston, Mass.
Burgwin, S. L., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Bush, J W., Southwestern Bell Tel. Co., Houston, Texas
Carson, R. N., Jr., Southwestern Bell Tel. Co., Houston, Texas
Cassil, C. C., Southwestern Bell Tel. Co., Houston, Texas
Child, J. E., Detroit Edison Co., Detroit, Mich.
Chrestensen, C. E., Milwaukee Elec. Railway & Light Co., Milwaukee, Wis.
Christison, D. C., Wisconsin Power & Light Co., Madison, Wis.
Cole, J. E., Waltham Watch Co., Waltham, Mass.
Coles, C. H., Brooklyn Edison Co., Brooklyn, N. Y.
Collinot, M. A., Chas. Engelhard, Inc., Newark, N. J.
Connor, W. F., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Cope, R. D., Houston Wood Preserving Co., Dallas, Texas
Cross, P. C., General Electric Co., Kansas City, Mo.
Cross, R. D., Alabama Power Co., Birmingham, Ala.
Dalby, H. W., Portland Electric Power Co., Portland, Ore.
Defries, R. G., Canadian General Electric Co., Toronto, Ont., Can.
del Valle Goerry, E., Mexican Tel. & Tel. Co., Mexico, D. F., Mex.
Diaz, E., United Scientific Laboratories, New York, N. Y.
Dickinson, R. C., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Dodds, G. B., Duquesne Light Co., Pittsburgh, Pa.
Dorn, H. V., 1 Prospect Park West, Brooklyn, N. Y.
Dyer, L. W., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Fannon, J. L., 34 Liberty Ave., W. Somerville, Mass.
Farry, O. T., Wagner Electric Corp., St. Louis, Mo.
Fathauer, W., Chicago Surface Lines, Chicago, Ill.
Finehout, F. R., Esterline Angus Co., Speedway City, Ind.
Firestone, S., Detroit Edison Co., Detroit, Mich.
Fischer, M , New York Edison Co., New York, N. Y.
Forbes, G., New York Telephone Co., New York, N .Y.
Fowler, G. F., Bell Telephone Laboratories, New York. N. Y.
Fuller, R. E., New York Edison Co., New York, N. Y.
Furth, E. L., Washington University, St. Louis, Mo.
George, S. A., Southwestern Bell Tel. Co., Houston, Texas
Gordon, N. B., Trumbull Electric Mfg. Co., Plainville, Conn.
Grace, W. J., Wm. K. Grace Engg. Co., Dallas, Texas
Graham, M. R., Commonwealth Power Corp., Jackson, Mich.
Grant, M. S., O. M. Matzen & Co., New York, N. Y.
Green, C. M., Jr., Radio Sales & Service Co., Orlando, Fla.
Grenfell, R. R., Einsman Magneto Corp., Brooklyn, N. Y.
Halberg, M. N., General Electric Co., Schenectady, N. Y.
Hand, A. R., General Electric Co., Schenectady, N. Y.
Hartt, J S., (Member), 610 Gay Bldg., Madison, Wis.
Heiser, E. S., U. S. Dept. of Commerce, St. Paul, Minn.
Hicks, B. C., Shawinigan Water & Power Co., Montreal, Que., Can.
Hill, W. B., Century Electric Co., Houston, Texas
Hoffman, S. G., 802 Howard Ave., Brooklyn, N Y.
Hulstede, G. E., Pacific Tel. & Tel. Co , San Francisco, Calif
Iams, H. A., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Jennings, J. E., Southwestern Bell Tel. Co., Houston, Texas
Johnson, W. C., Jr , General Electric Co., Schenectady, N. Y.
Kaestle, F. L.,* Yale University, New Haven, Conn.
Kahn, L., Rutgers University, New Brunswick, N. J.
Keller, C. H., 215 N. Front St., Columbus, Ohio
Kitchin, D. W., Simplex Wire & Cable Co., Cambridge, Mass.
Kniphuisen, R. F., American Tel. & Tel. Co., New York, N. Y.
Koch, G. S., Charles W. Jones, Attorney-at-Law, Washington, D C.
Koontz, R. M., Koontz-Wagner Elec. Co., So. Bend, Ind.
Krift, R. B., Union Gas & Elec. Co., Cincinnati, Ohio
Ligh, C., Piezoelectric Laboratories, New Dorp, S. I., N. Y.
Lyon, D. A., Philadelphia Suburban-Counties Gas & Elec. Co., Norristown, Pa.
MacHaffie, F. B., Rensselaer Polytechnic Institute, Troy, N. Y.
Maggi, E. C., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Mather, T. T., Public Service Elec. & Gas Co., Passaic, N. J.
McNeil, B., Commonwealth Edison Co., Chicago, Ill.
Meador, B. F., General Electric Co., Kansas City, Mo.
Merrill, O. E., Mass. General Hospital, Boston, Mass.
Miller, H. C., (Member), Southwestern Lt. & Pr. Co., Lawton, Okla.
Morey, C. H., Brooklyn Edison Co., Brooklyn, N. Y.
Newton, O. A., Public Service Elec. & Gas Co., Irvington, N. J.
O'Donnell, E. D., Southwestern Bell Tel. Co., Houston, Texas
Olson, F. G., Houston Lighting & Power Co., Houston, Texas
O'Toole, M., Ohio Brass Co., Mansfield, Ohio
Palmer, J. H., General Electric Co., Schenectady, N. Y.
Peters, R. H., Southwestern Bell Tel. Co., Houston, Texas
Pfalzgraff, R. M., General Electric Co., Lynn, Mass.
Pickett, G., U. S. Navy Dept., Navy Yard, New York, N. Y.
Puente, M. J., Compania Cervecera Internacional, Havana, Cuba
Reinken, L. W., American Tel. & Tel. Co., New York, N. Y.
Riethmiller, E. R., Cardon Corp., Jackson, Mich.
Rogers, A. H., New England Public Service Co., Augusta, Me.
Rojos, L., Pan American Union, Washington, D. C.
Roth, J. W., A. T. & S. F. Railroad Co., Amarillo, Texas
Schomer, J. M., Western United Gas & Elec. Co., Aurora, Ill.
Schumacher, A. E. W., New York Telephone Co., Mt. Vernon, N. Y.
Seaman, B. C., Elliott Co., Ridgway, Pa.
Seletzky, A. C., Johns Hopkins University, Baltimore, Md.
Sherman, K. S., General Electric Co., Oakland, Calif.
Sherwood, W. W., Yale University, New Haven, Conn.
Siddons, E. C., United Elec. Lt. & Pr. Co., New York, N. Y.
Smalley, W. E., Pennsylvania Power & Light Co., Hazleton, Pa.
Smith, F. W., Lafayette College, Easton, Pa.
Smith, T. Q., American Brown Boveri Electric Corp., New York, N. Y.
Snyder, J. S., (Member), Philadelphia Electric Co., Philadelphia, Pa.
Snyder, W. E., Pennsylvania Power & Light Co., Allentown, Pa.
Somoskie, P. A., Electrical Engineer & Contractor, Shamokin, Pa.
Sparks, R., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Staacke, H. F., Westinghouse Elec. & Mfg. Co., Houston, Texas
Starr, T. S., University of Akron, Akron, Ohio
Stocks, B. R., Kansas City Pr. & Lt. Co., Kansas City, Mo.
(Applicant for re-election.)
Stone, W. A., Purdue University, Lafayette, Ind.
Swift, H. L., Cincinnati Street Railway Co., Cincinnati, Ohio
Tadlock, W. L., Knoxville Power & Light Co., Knoxville, Tenn.
Tanner, S. C., Radio Corp. of America, Bolinas, Calif.
Tarpley, R. E., University of Illinois, Urbana, Ill.
Tchinnis, P. M., Brooklyn Edison Co., Brooklyn, N. Y.
Thomson, W. L., Cornell University, Ithaca, N. Y.
Toth, E., Bakelite Corp., Bloomfield, N. J.
Underwood, H. C., Puget Sound Power & Light Co., Everett, Wash.
Vera, J. E., Mexican Tel. & Tel. Co., Mexico, D. F., Mexico
Verman, L. C., Cornell University, Ithaca, N. Y.
Viessman, W., (Member), City of Baltimore, Baltimore, Md.
Wagner, H. H., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Warner, L. C., Western Electric Co., Inc., New York, N. Y.
Willis, R. S., Southwestern Bell Tel Co., Houston, Texas
Winterhalter, W. E., General Electric Co., Chicago, Ill.
Wright, S. H., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
York, V. O., Detroit Institute of Technology, Detroit, Mich.
Total 133.

Foreign

Abideen, S., Public Works Dept., Nagpur, Central Provinces, India
Bewick, R., Municipality of Middelburg, Middelburg, (C. P.), So. Africa
Branch, L. W., Hawaii Telephone System of the Mutual Telephone Co., Hilo, Hawaii
(Applicant for re-election.)
Coffey, L., Sydney Municipal Council, Sydney, Australia

Evans, A. W., North Metropolitan Elec. Pr. Supply Co., Buntingford, Herts., Eng.
Hano, I., Waseda University, Tokyo, Japan
Harmer, L. B., Post Office Telephones, Newcastle-on-Tyne, Eng.
Total 7.

STUDENTS ENROLLED

Abrahamson, Edward F., University of California
Ackor, William R., Newark College of Engineering
Adams, Myron D., Worcester Polytechnic Inst.
Adams, Watson C., University of New Hampshire
Agan, James B., University of Wisconsin
Albright, Robert B., Bucknell University
Allen, Roy E., University of Oklahoma
Allgeier, Stanley W., State College of Washington
Alverson, Robert M., University of Kentucky
Amtsberg, Lester A., Case School of Applied Science
Anderson, Gustaf A., University of California
Anderson, Harold T., University of Idaho
Anderson, Samuel W., University of Kentucky
Andrews, Fred O., Rose Polytechnic Institute
Anthony, Clarence W., University of Oklahoma
Appell, William M., Rice Institute
Arndt, Mark H., University of California
Arnold, Shirley, University of Santa Clara
Ashbaugh, Elwood, Engg. School of Milwaukee
Ashla, Neeland, Oregon State College
Ashmead, Eugene, Ohio State University
Atwood, Bryce O., University of New Hampshire
Backer, Labon, Virginia Polytechnic Institute
Baer, Werner K., Newark College of Engineering
Bailey, Donald S., University of Idaho
Bailey, Emory P., University of Maine
Bair, Herbert W., Pennsylvania State College
Baker, Albert E., Rose Polytechnic Institute
Ballard, Lawrence E., University of Kentucky
Bange, Richard M., Pennsylvania State College
Barker, Virgil R., Ohio State University
Barnes, Edgar C., Pennsylvania State College
Barnes, George W., University of Kentucky
Bartlett, Walter S., University of New Hampshire
Baston, Whitney M., University of Maine
Bates, Harold C., Worcester Polytechnic Institute
Bates, Stephen C., Oregon State College
Beckley, Frank E., Jr., University of Vermont
Benner, Arthur H., Engg. School of Milwaukee
Bennett, Ernest W., Kansas State Agri. College
Berry, J. S., University of California
Bevill, James B., Clemson Agri. College
Bingham, Clifford J., University of Michigan
Bolton, Curtis F., University of California
Boston, John P., University of Kentucky
Boughtwood, Edwin, Northeastern University
Bowers, Elwell S., University of California
Boyd, Clarence N., Colorado Agricultural College
Boylan, Horace E., Engg. School of Milwaukee
Boyles, Abbott W., University of New Hampshire
Bozeman, Richard W., University of Kentucky
Bradbury, Gordon C., Washington State College
Britton, J. A., Drexel Institute
Brockmeyer, H. R., Engg. School of Milwaukee
Brosman, Granville P., Rose Polytechnic Institute
Brown, Clifford E., University of Idaho
Brubaker, Jasper L., Kansas State Agri. College
Buckminster, Hartford E., University of Arkansas
Buge, Albie, Engineering School of Milwaukee
Burelbach, Fred M., Oregon State College
Burrell, John E., University of Washington
Bush, George L., Worcester Polytechnic Institute
Bussell, Cecil W., University of Wisconsin
Butler, John H., University of Kentucky
Calhoun, Charles M., North Carolina State College
Carlson, Lawrence E., University of California
Carpenter, Haskell, University of Oklahoma
Carter, Herman T., Ohio State University
Castler, Joseph H., University of California
Caulkins, Lloyd E., So. Dak. State School of Mines
Chase, Willard F., University of Michigan
Chia, Y. L., Newark College of Engineering
Churchill, Alfred L., University of California
Cilley, Putnam, Mass. Institute of Technology
Clark, Albert C., Oregon State College
Clark, Galen B., Rose Polytechnic Institute
Clark, Herbert S., University of Idaho
Clark, Paul G., University of Detroit
Clay, Murray G., Lafayette College
Clemens, Eli W., Virginia Polytechnic Institute
Coe, John M., University of Missouri
Coggins, Arthur R., University of Maine
Cole, John H., University of Oklahoma
Coleman, William N., Clemson Agri. College
Coon, Alton H., Rhode Island State College
Cornett, Ewel B., University of Kentucky
Counts, William L., University of Oklahoma
Coupland, Bertram R., California Inst. of Tech.
Crenshaw, Ernest D., University of Arkansas
Cropper, Robert O., University of Kentucky
Crosby, Leslie W., Northeastern University
Culbertson, M. F., University of Oklahoma
Cullinan, John A., Northeastern University
Cunningham, Robert M., Haverford College
Curry, Elden M., University of Oklahoma
Daebeler, Otto, Drexel Institute
Dalrymple, Donald D., Penn. State College
Daniel, Claude W., University of Kentucky
Darsie, Robert C., University of Kentucky
Davis, Paul A., Worcester Polytechnic Institute
Deming, Arthur F., University of California
Derry, John A., Rose Polytechnic Institute
Desjardins, George E., University of Maine
Dick, Charles L., University of Idaho
Dickinson, Clarence R., University of Wisconsin
Dickinson, Neil K., University of Akron
Dicus, Fred E., Jr., University of Idaho
Dodson, Wayne E., Rose Polytechnic Institute
Doerle, Walter C., University of California
Donlon, John E., University of Idaho
Dowen, Robert H., Rose Polytechnic Institute
Drake, Leslie P., University of Wisconsin
Duering, Carl F., University of California
Edwards, Willard E., University of Oklahoma
Ellington, Tom S., Jr., North Carolina State Col.
Ellison, Ralph A., Alabama Polytechnic Institute
Engel, Ernest D., University of Washington
Erickson, Harvey, State College of Washington
Eubanks, Elbert E., University of Arkansas
Ewing, George McN., University of Missouri
Fanson, Wayne R., University of Oklahoma
Fausey, Carl A., Engg. School of Milwaukee
Fernlund, Carl A., Case School of Applied Science
Fettig, Joseph J., Purdue University
Finley, Samuel F., University of California
Fisher, Sol, University of Michigan
Fister, Fred M., University of Kentucky
Fredendall, Beverly, California Inst. of Tech.
Fried, Harold V., University of Kentucky
Funkhouser, Albert W., Purdue University
Fuss, William H., University of Michigan
Gable, Albert C., Georgia School of Technology
Garrison, Homer D., University of Washington
Geddings, Marvin T., Clemson Agri. College
Gill, Charles W., University of Kentucky
Gilmore, Verrill B., University of Maine
Girard, Walter A., University of Oklahoma
Goddard, DeWitt R., Worcester Polytechnic Inst.
Goerger, Orville R., Washington University
Goldman, Harry L., Worcester Polytechnic Inst.
Goldstein, Mandel N., University of Wisconsin
Goodale, R. Wayne, Oregon State College
Gorbandt, Everett T., University of Kentucky
Gorsuch, Harry R., University of Missouri
Grant, John R., University of Michigan
Graves, James A., Clemson Agri. College
Gravitt, Frank H., University of Kentucky
Gray, Elza, University of Oklahoma
Haeggquist, Willard L., Engineering School of Milwaukee
Haisch, Frederick, Drexel Institute
Halvarson, Thure, University of Washington
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JOURNAL

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DIGEST OF CURRENT INDUSTRIAL NEWS

NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Motors.—Bulletin 1118-E. Describes Allis-Chalmers polyphase induction motors, types AR and ARY, with either sleeve or tapered roller bearings. Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Electric Railway Equipment.—Supplement No. 2 to Catalog No. 20, 62 pp. Describes O-B electric railway equipment and accessories. Ohio Brass Company, Mansfield, Ohio.

Electric Equipment for Petroleum Industry.—Bulletin GEA-922, 76 pp. Describes G-E apparatus for the petroleum industry. Specific applications are illustrated. General Electric Company, Schenectady, N. Y.

Motors.—Bulletin L-20386, 4 pp. Describes Type CS linestart, squirrel cage motors. Westinghouse Electric & Manuturing Company, East Pittsburgh, Pa.

Texrope Drives.—Bulletin 1228-H, 16 pp. Describes the Allis-Chalmers Texrope drive for transmitting power to industrial equipment with a reduction in speed from 1:1 up to 7:1 ratio. Numerous applications of the Texrope drive are illustrated. Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Industrial Lighting.—Booklet 448-A, 24 pp. Lists many recent developments not mentioned in recent publications of the same character, a number of which have been developed for specific applications in various locations. Holophane Company, Inc., 342 Madison Avenue, New York.

Linestarters.—Bulletin L-20394, 4 pp. Describes application and distinctive features of Westinghouse class 11-200 linestarters for squirrel cage and wound rotor induction motors. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Heating Units.—Catalog 7418, 32 pp. Describes Sirocco Unit Heaters for floor and ceiling applications. The heater has been designed with the requirements of the industrial plant heating system chiefly in mind. American Blower Corporation, Detroit, Michigan.

Collector Rail Supports.—Bulletin 31-GA (addenda to Bulletin 31-B). Describes a new line of 600-volt collector rail supports for cranes, ore bridges and industrial railroad service. It contains a table on ratio of steel rail to copper resistance. Delta-Star Electric Company, 2400 Block Fulton Street, Chicago, Ill.

Polyphase Ammeter.—Supplement No. 1 to Bulletin No. 450. Describes a new and novel instrument, the type HEA-3 polyphase ammeter for three-phase alternating current circuits. With this instrument it is possible to take readings simultaneously in each of the phases of a three-phase circuit. Roller-Smith Company, 12 Park Place, New York.

Motors.—Bulletin, 4 pp. Describes type RS repulsion start induction single-phase motors of the brush lifting type, from ⅛ to 40 hp. Built for all standard speeds, voltages and sizes. Bulletin, 2 pp. Describes Century type SC squirrel-cage induction polyphase motors, from ¼ to 200 hp. Century Electric Company, 1827 Pine Street, St. Louis, Mo.

Circuit Breakers.—Bulletin 220, 8 pp. Describes the new U-Re-Lite all-steel distribution groups. The bulletin deals primarily with the group method of mounting U-Re-Lites on all-steel frames. Capacities range up to 1250 amperes in two-, three- and four-pole forms for a-c. circuits of 550 volts and less, and d-c. circuits of 25 volts and less. I-T-E Circuit Breaker Company, 19th and Hamilton Sts., Philadelphia, Penn.

NOTES OF THE INDUSTRY

Electric Machinery Manufacturing Company, Minneapolis, Minn., announces that A. B. King, formerly in charge of eastern sales with headquarters in New York, has resigned to become president of the A. C. Morse Company who are sales representatives for the Electric Machinery Manufacturing company at New Haven, Conn.

G-E Appoints D. C. Spooner, Jr.—David C. Spooner, Jr., for the past four months acting publicity manager of the Merchandise Department, General Electric Company, at Bridgeport, Conn., has been appointed manager of the publicity section. He was formerly assistant to the publicity manager, A. L. Atkinson, who, in June, was made manager of Cleaner Sales.

The Wagner Electric Corporation, St. Louis, announces the removal of its Los Angeles branch office and service station to 1220 S. Hope Street. The change was made necessary by the rapid growth of business in southern California and Arizona.

H. N. Felton, branch manager of the Milwaukee office since 1927 has been made branch manager of the New York office. F. T. Coup, in charge of the Cincinnati office since 1921 has been moved to the Milwaukee office as branch manager there. Paul Forsyth has been appointed branch manager of the Cincinnati office.

Anaconda Copper Rebuilds Plant.—The Anaconda Copper Mining Company, through its subsidiary, the American Brass Company, of Waterbury, Conn., is rebuilding its electric cable plant at Hastings-on-Hudson, N. Y. This plant will be constructed to produce the highest quality power cable of all types. The best insulating machinery and the most approved drying and impregnating apparatus are to be installed. A testing laboratory for the most advanced high-tension cable work and for the examination of insulating oils, paper and cable sheath is being provided. The Hastings plant, originally operated under the name of the National Conduit & Cable Company, is one of the oldest makers of power cables in the industry. It is also one of the largest copper cable mills in the country. The products run annually around 100,000,000 pounds. This figure includes other materials, as well as copper in the cable output.

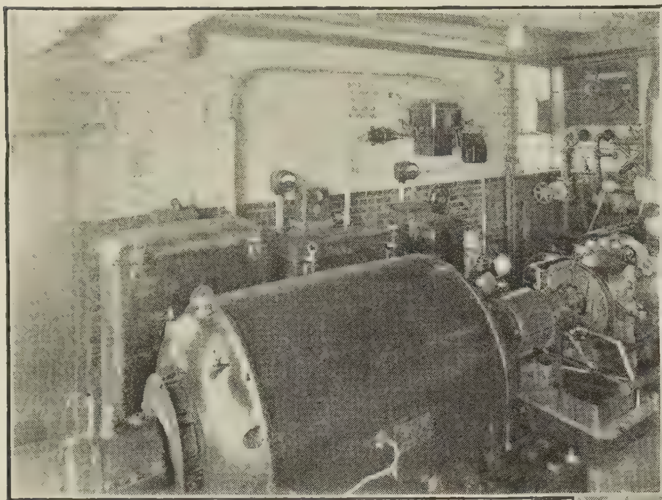
Lincoln Meter Company, Inc., Appoints L. Dana Johnson.—Announcement has been made by the newly-formed Lincoln Meter Company, Inc., of Springfield, Ill., organized to market Lincoln maximum demand meters and other Lincoln products in the United States, that L. Dana Johnson has been appointed sales manager. Mr. Johnson was formerly connected with the Sangamo Electric Company in Springfield and later as manager of its interests in the far East.

The Lincoln thermal maximum demand meter is named after its inventor, Paul M. Lincoln, president of the new company, who is widely known throughout the electrical industry and is at present Director of Electrical Engineering at Cornell University. Mr. Lincoln is a past-president of the A. I. E. E. Mr. R. C. Lamphier, vice-president of the new company, is also well known as president of the Sangamo Electric Company of Springfield. Although familiar to engineers in the United States, Lincoln meters have made their name in Canada. For nine years the sales curve has steadily pointed upward. On Canadian power and commercial loads, these meters are successfully helping to eliminate estimating in billing.

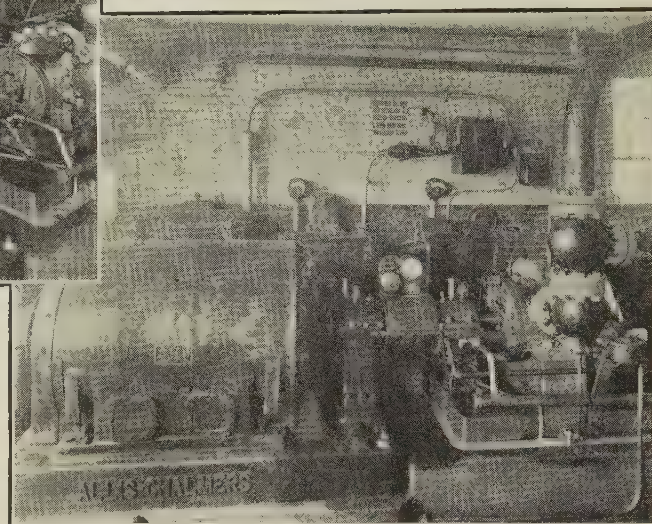
Manufacturing facilities will be in shape for deliveries from Springfield about January 1. Special machinery similar to that in the Canadian factory is being installed. Meters available for distribution on the first of the new year include the single-phase two- and three-wire ampere-demand-type indicating amperes of demand, the polyphase type indicating watts or volt-amperes of demand, the graphic or recording types which chart a clear line, easily and accurately read. This graphic meter will be made in two types, either measuring amperes of demand, or watts or volt-amperes of demand. In addition, the Lincoln split-core transformer will be available—the device which when used with the single-phase demand ammeter enables the determination of loads on distributing transformers, lines and large machines with loads ranging from 35 to 1000 amperes.


KERITE
In 1752 Franklin invented the Lightning Conductor and identified lightning and electricity. A century later, Day invented
KERITE
Over half a century of experience has identified it as the most reliable and permanent insulation for Electrical Conductors
DAYS KERITE
KERITE COMPANY
NEW YORK
CHICAGO

On difficult starting jobs



Two views of the Sun Oil Company's three step, oil-immersed 2300 volt starter for a 500 HP, 3600 RPM, synchronous motor.



like this,

EC&M Motor Control excels

Here is a 5-stage centrifugal pump that runs at 3600 RPM and delivers oil to the stills of the Marcus Hook Refinery of the Sun Oil Company at 1300 pounds pressure. The 500 HP, 2300 volt synchronous motor that drives it is started automatically when a master switch is thrown, by EC&M oil-immersed, flame-proof starting equipment.

The starting of such a machine is not easy, for the load on a centrifugal pump increases as the cube of the speed, thus making it difficult to get the motor up to a speed at which it will pull into synchronism. EC&M engineers solved the problem, however, by providing three-step acceleration whereby smooth acceleration to synchronism is assured, line surges are eliminated and the same standards of EC&M flame-proof equipment, safe for use in explosive atmospheres such as may exist in this plant, were maintained.

The Electric Controller & Manufacturing Company specializes in the solution of difficult control problems. In many cases, production operations are made automatic, eliminating attendants, cutting down power consumption and peak demands and often avoiding the necessity for additional equipment.

EC&M Engineering Service is at Your Disposal.

THE ELECTRIC CONTROLLER & MFG. CO.

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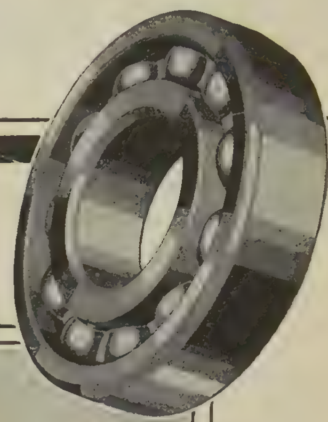
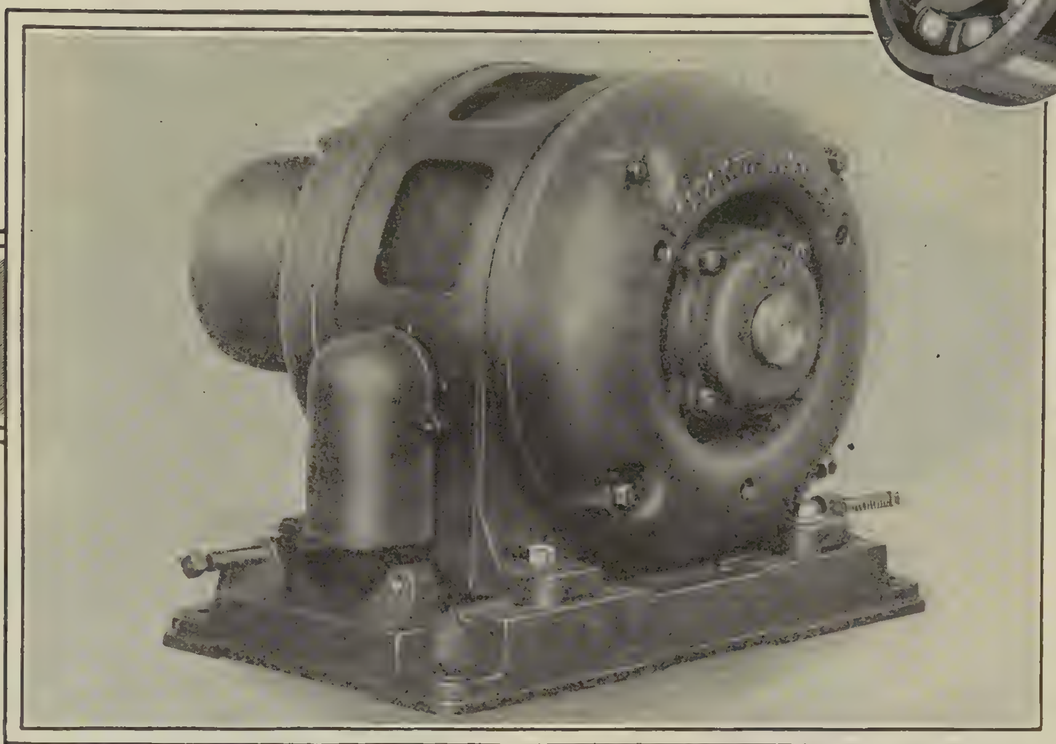
SALT LAKE CITY-228 SO. W. TEMPLE
TORONTO-REFORD BLDG.
PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
MONTREAL-DRUMMOND BLDG.
TULSA-217 E. ARCHER ST.

More than 50 Manufacturers of General Purpose Motors Use Ball Bearings





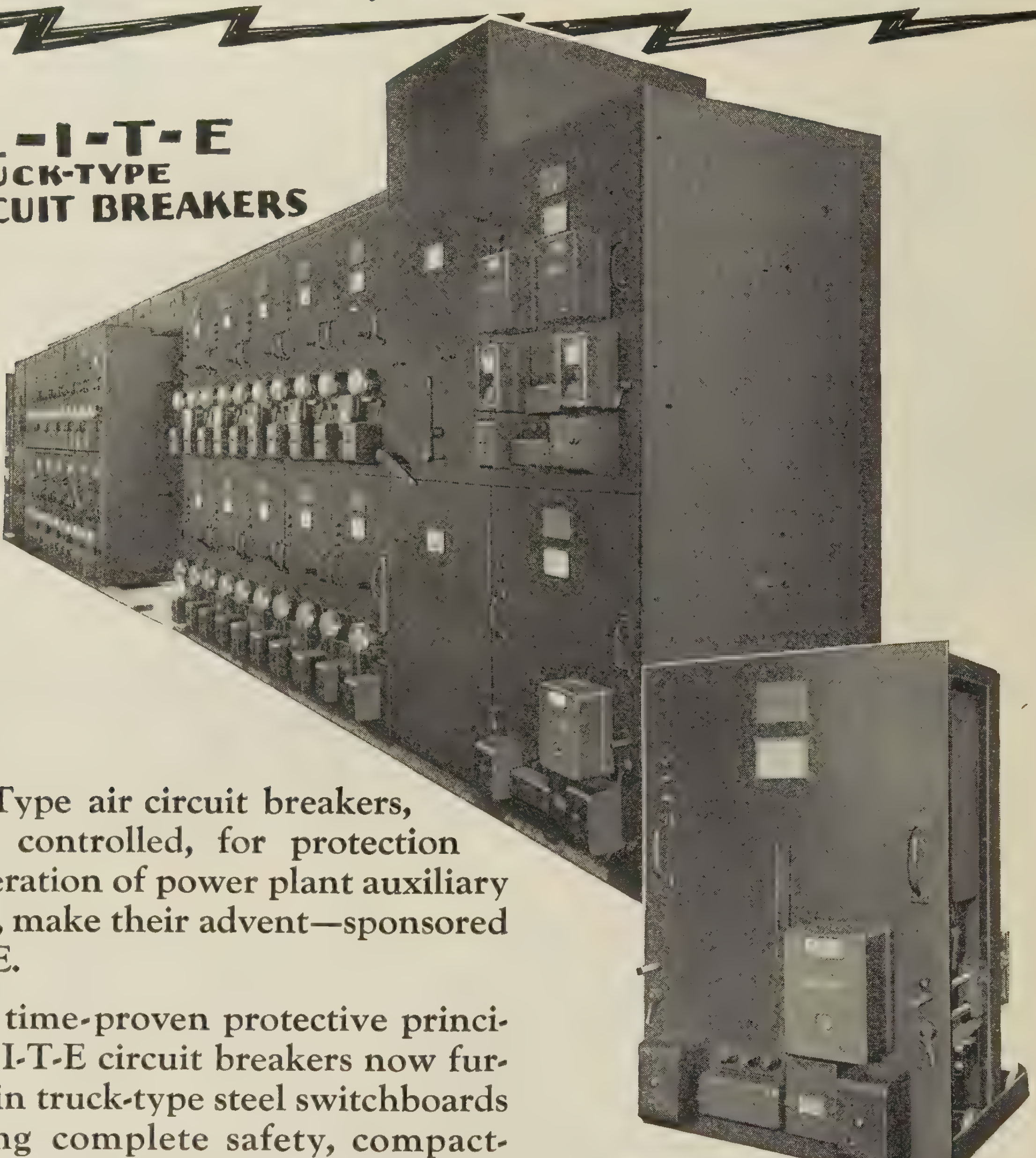
889

CROCKER WHEELER is one of more than fifty electric motor manufacturers who supply a series of general purpose electric motors with ball bearings as standard or optional equipment.

Motor users can not afford to overlook the economies of ball bearing equipped electric motors.

Write for "Booklet K" and "Cutting Your Cost," two publications of our Engineering Department explaining fully what these advantages are and how greatly they reduce motor maintenance costs. These are sent without cost or obligation upon your request.

THE NEW DEPARTURE MANUFACTURING CO.
Bristol, Connecticut
Chicago San Francisco Detroit



Dead or Alive—The STATISCOPE tells the story!

Safety
First

The MINERALLAC STATISCOPE

High Voltage Indicator

The STATISCOPE is designed to give positive indication of ALTERNATING CURRENT potentials of 2300 volts and upward

About as large as a fountain pen

The advantage of being able to detect the condition of any electrical part at a safe distance need not be pointed out.

Write for Bulletin No. 130

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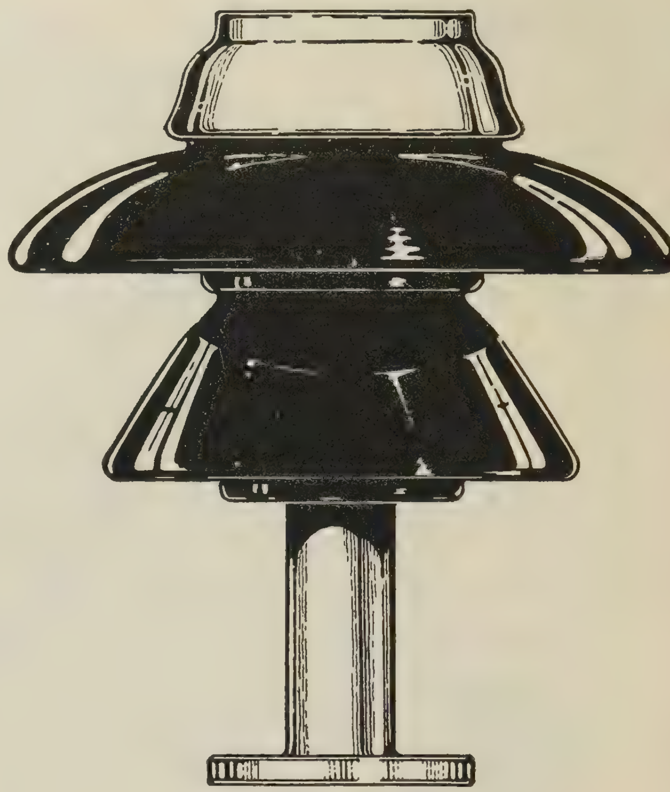
When service counts



LOCKE 10100

A representative Locke Switch Type Insulator.

There's a reason why more Locke Pedestal Type Insulators are used, than any other make. That reason is performance.

Whether in comparative tests in the laboratory, or actual service in the field, Locke Pedestal Type Insulators will demonstrate their superiority.

Proper design, perfect materials, rigid standards of manufacturing control, exact assembly and continuous tests and inspections, guarantee you the type of satisfactory performance you must have on your station equipment. When service counts, specify Locke.

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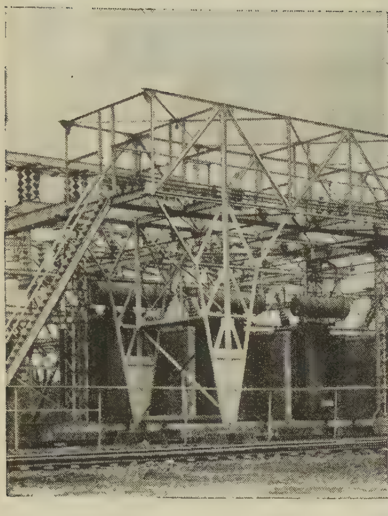


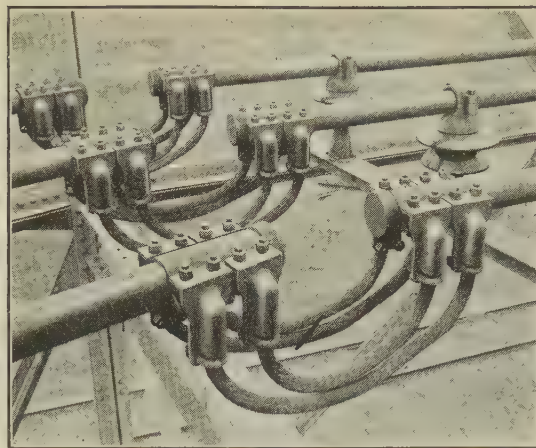
General view of the Essex 132 K. V. Outdoor Substation of Public Service Electric and Gas Company, designed and constructed by Public Service Production Company, Newark, N. J.

The secondary leads consist of three 3¼" O. D., 2¾" I. D. Anaconda Copper Tubes per transformer bank, spaced on 2'6" centers; length of space between insulator supports, 20 feet.

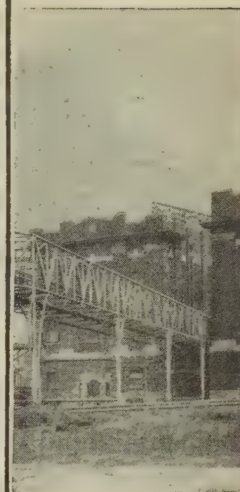
The high conductivity and uniform quality

of Anaconda Metals are the result of the coordinated control by a single organization which is responsible for every step in their production from mine to finished product.

A Technical Department is maintained to assist electrical engineers in the adaptation of copper and copper alloys to specific requirements. You are invited to make use of this service.



Detail of angle expansion joint.



Anaconda *high conductivity* Bus Tubes

TUBULAR conductors are more efficient for large alternating currents than solid conductors because of the tendency of the current to crowd itself away from the center of the conductor. This effect is especially noticeable above 2,000 amperes at 60 cycles and for smaller currents at higher frequencies.

The tubular shape is ideal for mechanical rigidity in all directions. Hard drawn copper tubes are more rigid and have higher tensile strength than soft drawn tubes, thus raising the yield point, but up to the yield point, sag is independent of tensile strength.

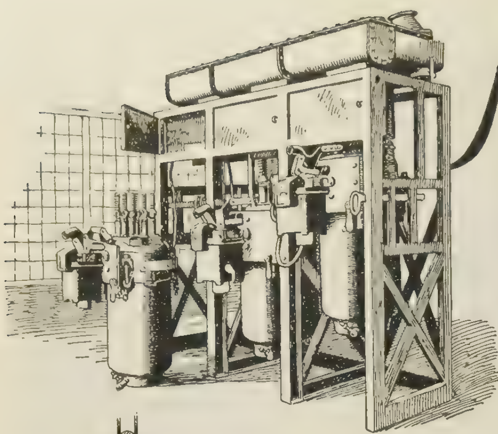
Anaconda high conductivity bus tubes have a minimum conductivity of 98% when hard drawn and 99% when annealed (hard drawn tubes are standard and will be supplied unless otherwise specified).

Bus tube connections are usually made with bolted or soldered fittings, but some engineers prefer to flatten the ends and join with bolts. Anaconda high conductivity tubes will flatten cold without cracking if finished soft or with a light draft.

THE AMERICAN BRASS COMPANY
GENERAL OFFICES: WATERBURY, CONNECTICUT

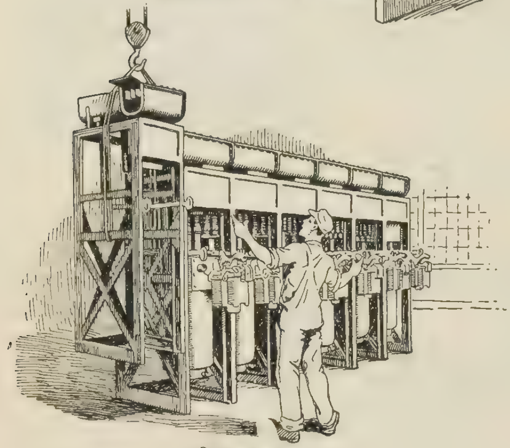
ANACONDA
COPPER ANACONDA BRASS

Metal-Clad



Safety for Operators

All live parts are completely enclosed while the equipment is in operation. Repairs can be made in safety while the breaker is disconnected.

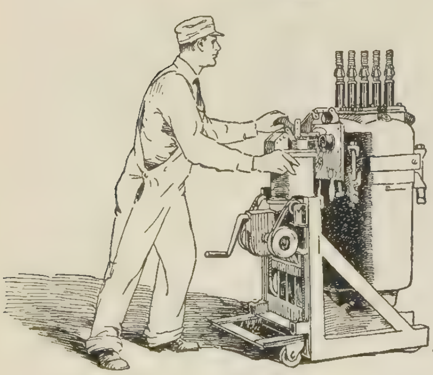


Simple to Install

Each unit includes an oil circuit breaker, buses, instrument transformers, disconnecting devices, and frame work completely assembled and wired ready to install.

Compact Construction

These units are so constructed as to require small floor space and still provide liberal clearances and ready accessibility.



Economy of Maintenance

A spare circuit breaker can be substituted quickly and easily when inspection or adjustment is necessary—and with but short interruption of service.

GENERAL

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

Switchgear

Safety for operators, simplicity of installation, compact construction and economical maintenance are among the advantages which characterize metal-clad switchgear.

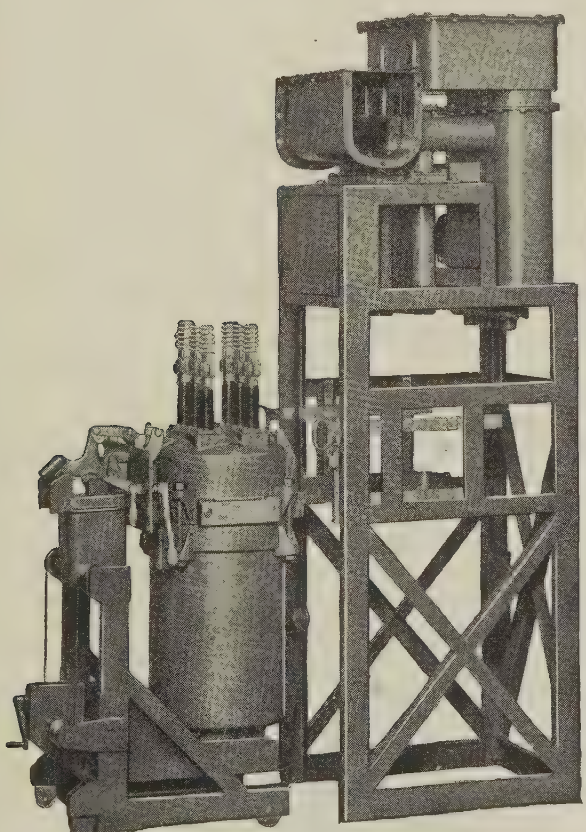
The design utilizes standard oil circuit breakers, supported in a frame of welded structural steel. This frame carries a cradle on which the breaker unit can be raised and lowered by means of an installing truck. The frame also carries the bus and instrument transformer compartments and the disconnecting devices.

To put the equipment in operation, the breaker unit on the installing truck is slid into the frame and raised until full contact is made. To withdraw the unit, this operation is reversed. Interlocks are provided to prevent insertion or withdrawal when a breaker is closed.

The main buses are covered with a molded insulation and enclosed in a metal bus compartment which may be filled with insulating fluid.

As each part is segregated in a metal compartment, fire risks from internal or external sources are minimized.

G-E switchgear specialists will explain to you the advantages of this equipment. Ask our nearest sales office for publication GEA-966.



View on Assembly Floor Showing Units under Construction

460-26

ELECTRIC

SALES OFFICES IN PRINCIPAL CITIES


SINCE 1912
Sixteen years ago the first line insulated with No. 11623's was installed. These insulators are still "on the job" and thousands of miles of line similarly insulated cover the country today. That the O-B principle of balanced design continue to predominate is best attested by the fact that approximately 1900 miles of line insulated with No. 11623's have been put in service in 1928.
Ohio Brass Company, Mansfield, Ohio
Canadian Ohio Brass Co., Limited
Ohio Brass Co.
NEW YORK CHICAGO PHILADELPHIA
PITTSBURGH ATLANTA CLEVELAND SAN FRANCISCO LOS ANGELES
PORCELAIN INSULATORS
LINE MATERIALS
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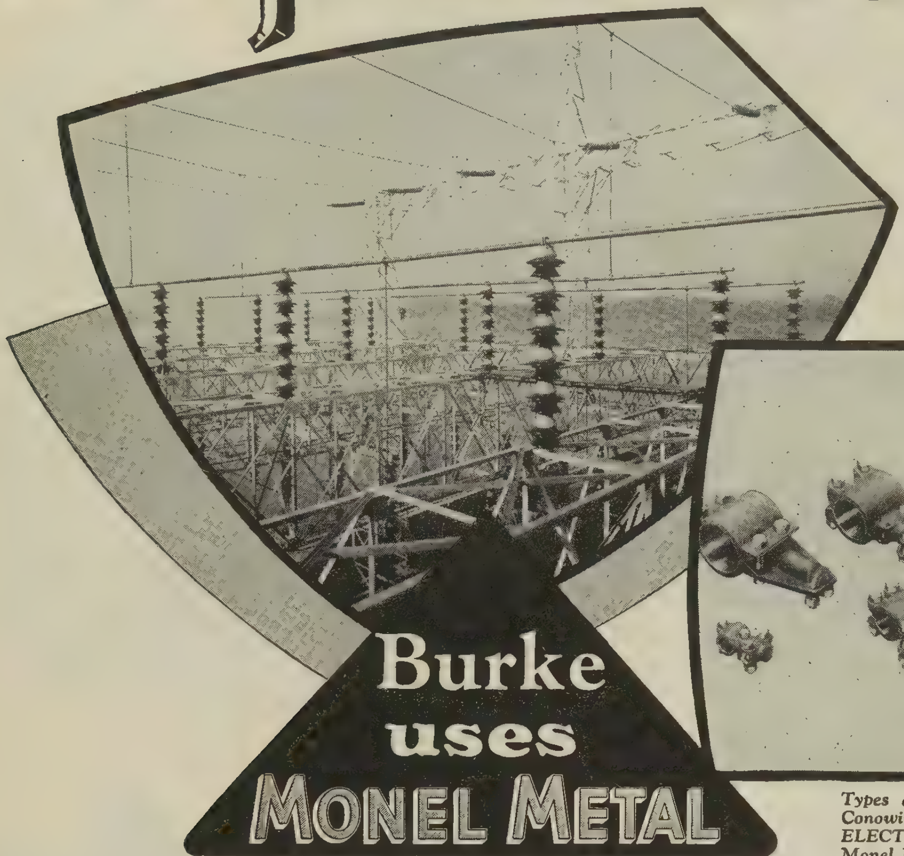
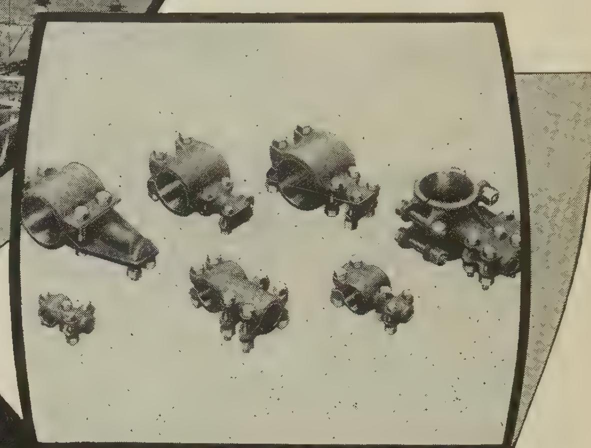
MINING MATERIALS
VALVES

dependable



At left: Bus support lines on Conowingo Station of the Philadelphia Elec. Co. designed and constructed by DAY & ZIMMERMAN ENG. & CONST. CO. of Philadelphia. Photo shows connectors made by the Burke Electric Co., and fitted with Monel Metal bolts.



Types of Cable Connectors installed at Conowingo Station. Made by BURKE ELECTRIC CO. of Erie, Pa., and fitted with Monel Metal bolts and nuts. Catalog describing these connectors will be gladly sent on request. Address Burke Electric Co., Erie, Pa. Ask for Bulletin C. T. 4.

—at CONOWINGO,

Monel Metal bolts on bus support lines

THE high tension equipment furnished by the Burke Electric Company is the product of years of experience in the design and manufacture of connectors for the electrical industry.

Therefore, it is significant that the Burke connectors at Conowingo—1928's outstanding electrical achievement—are fitted with Monel Metal bolts.

Monel Metal bolts, nuts, etc. are now supplied by leading manufacturers and specified by leading engineers to provide "strength under stress". They will not rust. They are not subject to corrosion-cracking. They are uniformly strong and tough.

When you plan installations that must stand up under stress and weather for years to come—when you plan installations that must provide uninterrupted, dependable service—take advantage of the availability of Monel Metal in all commercial forms—rod, sheets, wire, bolts, nuts, forgings, screws, castings, etc.

You can't go wrong in specifying Monel Metal—you are merely following the lead of manufacturers and engineers who have spent years in a search for the most dependable materials for high tension service.

SEND FOR "LIST B" OF MONEL METAL & NICKEL LITERATURE

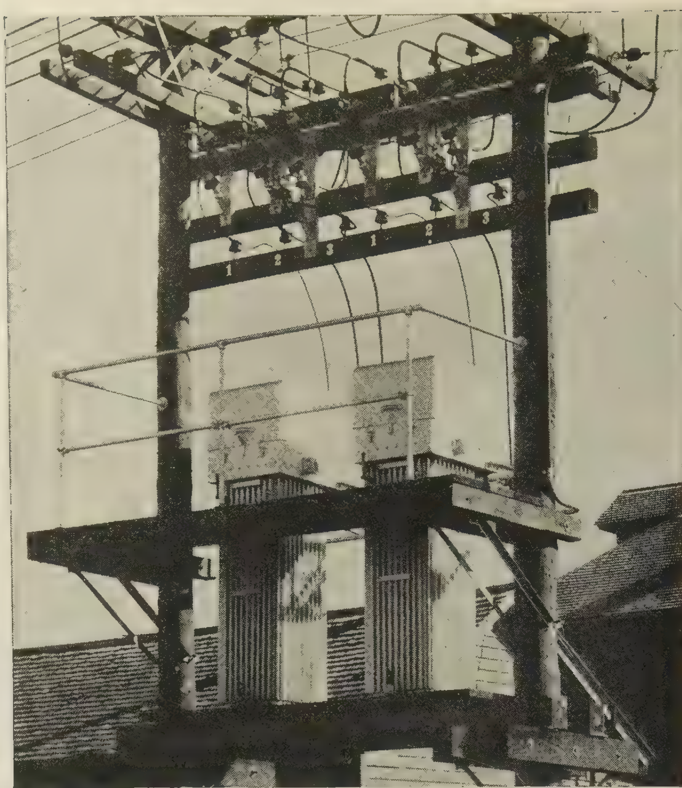
Monel Metal is a technically controlled Nickel-Copper alloy of high Nickel content. It is mined, smelted, refined, rolled and marketed solely by The International Nickel Company. The name "Monel Metal" is a registered trade mark.

MONEL METAL

INCO MONEL METAL TRADE MARK

THE INTERNATIONAL NICKEL COMPANY (INC.) 67 WALL STREET, NEW YORK, N. Y.

Westinghouse Feeder-Voltage Regulators STAND UP



These two 48 kv-a. Outdoor Type Regulators provide constant voltage on two single-phase feeders of the Gulf State Utilities Company, Beaumont, Tex.

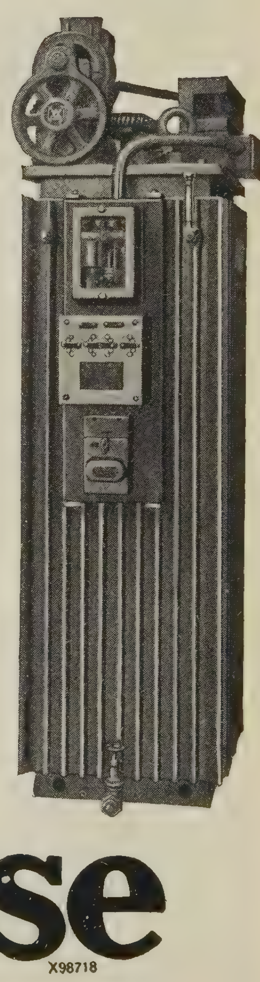
Economy with Westinghouse Regulators

INDUCTION Voltage Regulators usually will justify the cost of their installation on any feeder having a voltage variation of more than 3 per cent from its proper value.

However, to get the utmost return from such investment the regulators should—

Correct voltage changes promptly.
Hold the voltage within narrow limits.
Remain in adjustment.
Require minimum attention.
Have low maintenance cost.
Withstand feeder disturbances.
Be economical of power.

The fact that Westinghouse Induction Feeder Voltage Regulators meet all these requirements explains why so many engineers specify them.



Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania

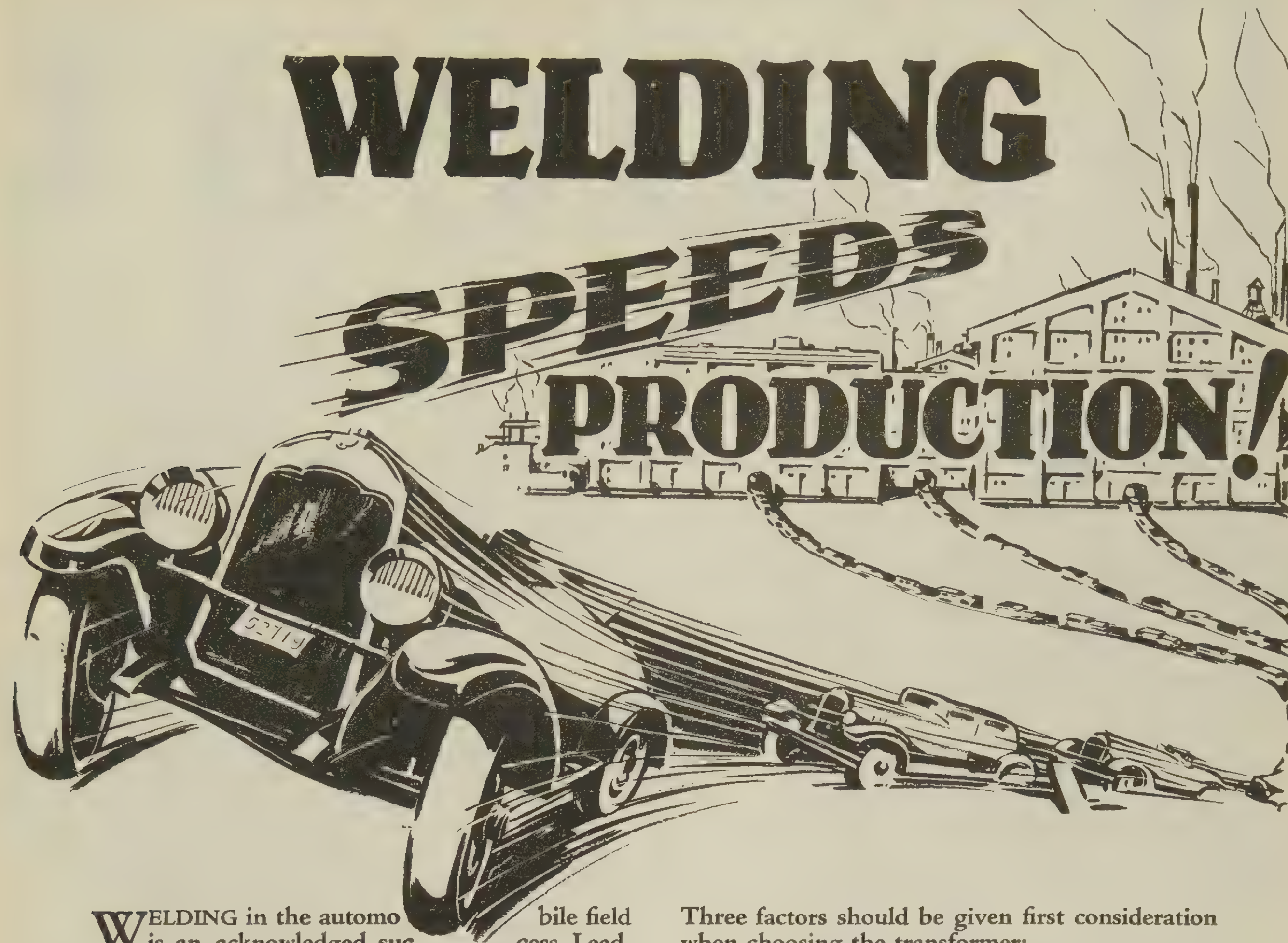
Sales Offices in All Principal Cities of the United States and Foreign Countries

Westinghouse

X98718


ALL 'ROUND ABILITY
Type F-120

{ONE OF A SERIES SHOWING AMERICAN TRANSFORMERS IN MANY DIVERSIFIED INDUSTRIES}



WELDING in the automobile field is an acknowledged success. Leading manufacturers attribute at least two major improvements directly to its introduction in their field:

1. Increased production (with increased profits)
2. Stronger, more rigid chassis, frames and bodies.

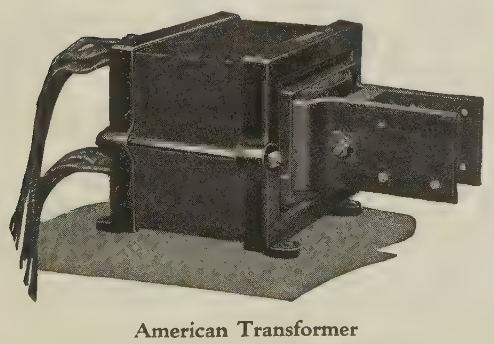
The welding equipment for this purpose must be chosen with care. Of special importance is the transformer used, for upon its efficient performance depends the strength of the weld.

Three factors should be given first consideration when choosing the transformer:

1. Efficiency— (wide range of voltage with a dependable control board)
2. Reliability—(24 hour service, without interruption, if necessary)
3. Economy — (long life with a minimum of repairs)

American Transformers are built to meet the individual requirements of welding machines for spot, seam, arc, flash and other welding methods. Bulletin 1040-J gives complete description of type CF which is used mainly for spot welding.

There is an American Transformer for every industrial service. Let our engineers advise you on *your* problem—no obligation, of course.



American Transformer
TYPE CF for welding machines

AMERICAN TRANSFORMER COMPANY

176 EMMET STREET NEWARK, N. J.

Representatives

Chicago, Ill.
L. C. Herrmann
4433 North Richmond Street
Ravenswood Station

Cleveland, Ohio
H. C. Boulton
1988 East 66th Street

Cincinnati, Ohio
Congleton Engineering Co.
914 Main Street

Pittsburgh, Pa.
Herr-Harris Company
910 Fulton Building

Knoxville, Tenn.
Arthur L. Pollard

Philadelphia, Pa.
L. D. Joralemon
112 South 16th Street

Montreal, Canada
W. O. Taylor & Co., Ltd.
415 Canada Cement B'ldg.

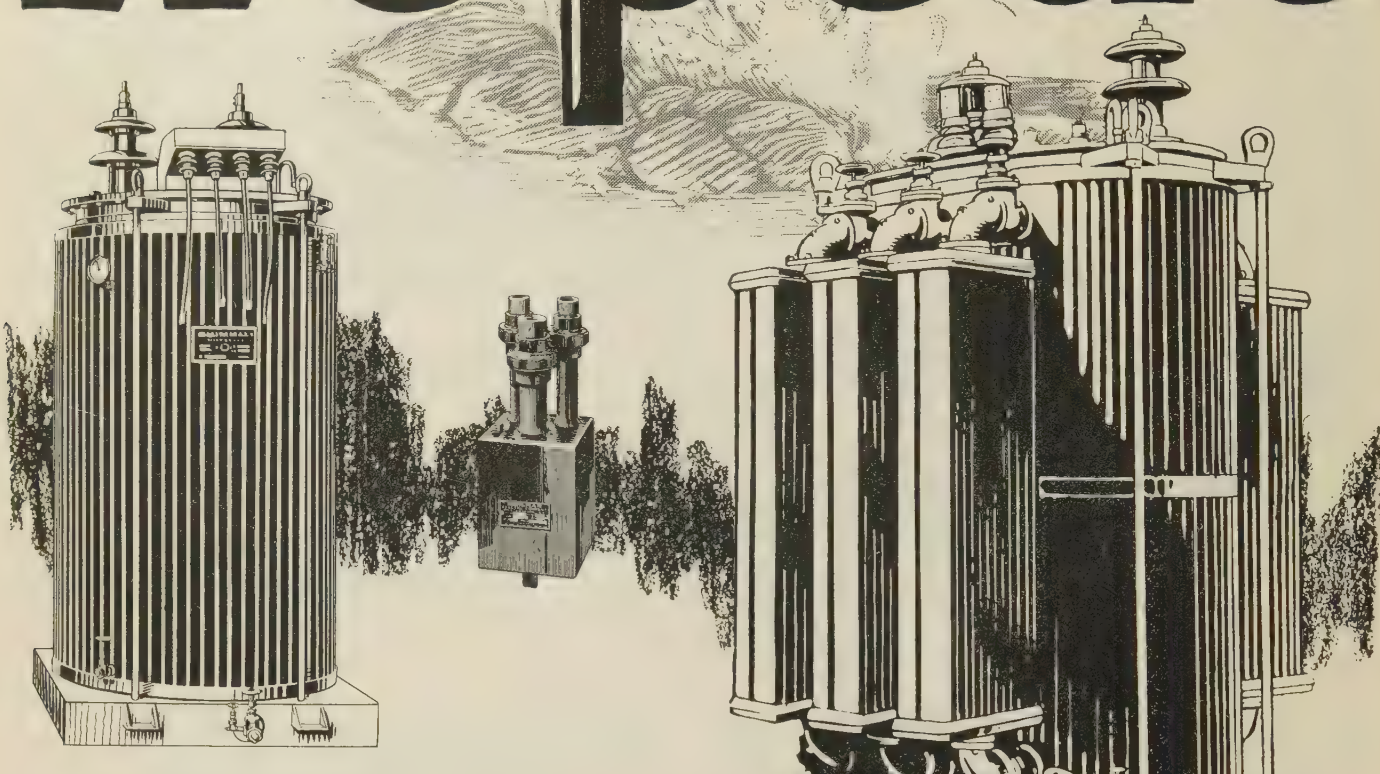
Minneapolis, Minn.
Elliott Equipment Co.
708-6th Avenue, South

San Francisco, Calif.
James H. Southard
682 Mission Street

St. Louis, Mo.
J. W. Jones
432 Pennant Building

AMERICAN TRANSFORMER

Repeat



A STEADY increase in repeat business can mean just one thing—satisfactory performance of the product in the buyer's service.

The power companies that have Kuhlman Transformers in service are coming to Kuhlman again-and-again for their transformer requirements. They have first-hand data regarding the unfailing reliability and operating economy of Kuhlman Power, Distribution, and Street Lighting Transformers.

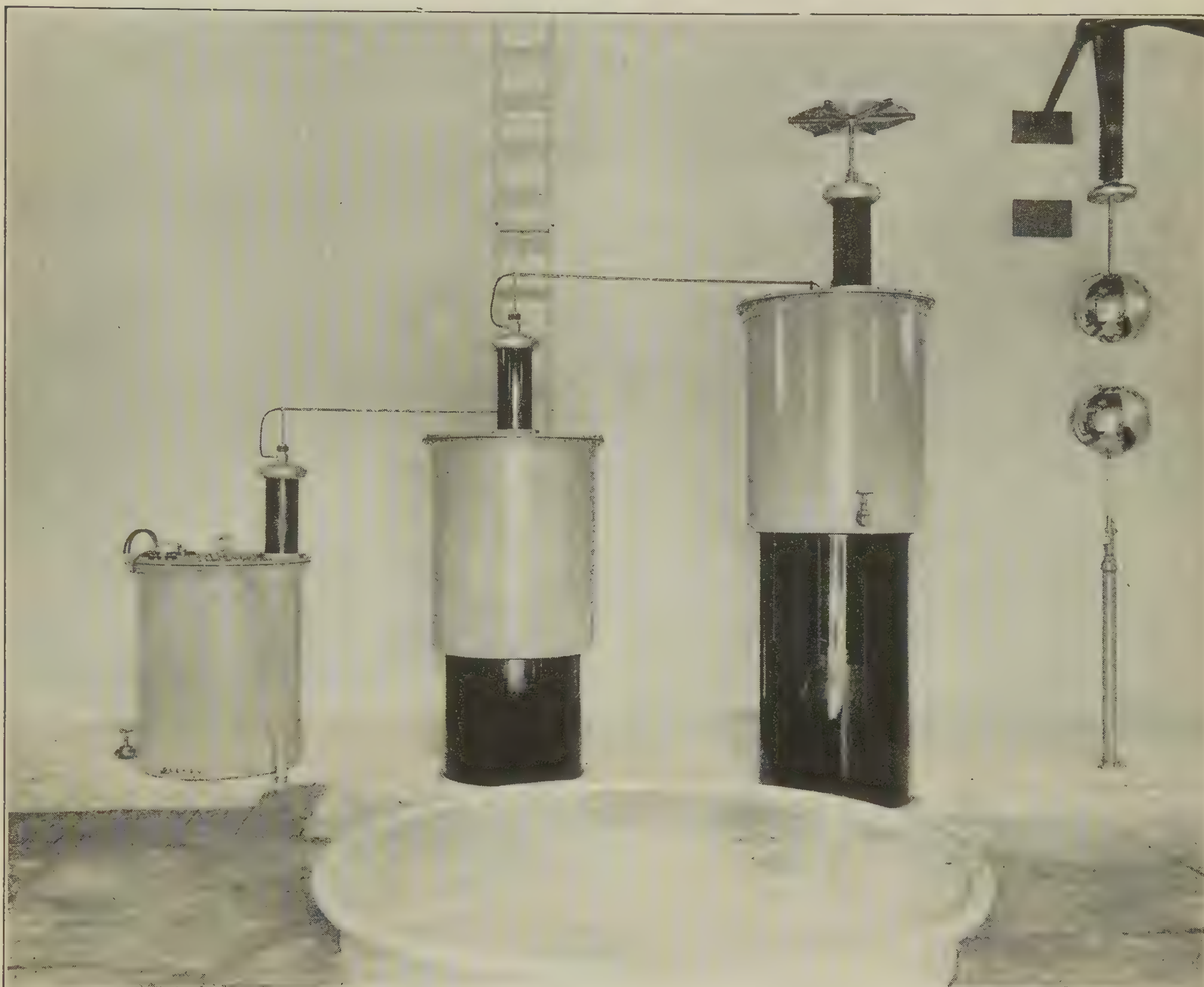
Even more gratifying than the steady growth in the demand for Kuhlman Transformers is the increasing percentage of "repeat" orders—orders from power companies, industrials, railways, electrical contractors, etc. who have previously used Kuhlman Transformers.

KUHLMAN TRANSFORMERS

KUHLMAN ELECTRIC CO., Bay City, Michigan

Akron	High and Barges Sts.
Atlanta	411 Glenn Bldg.
Baltimore, Md.	421 W. Camden St.
Boston	69-71 High St.
Buffalo	280 Carolina St.
Chicago	844 Rush St.
Cleveland	627 Union Trust Bldg.
Dallas	1408 Allen Bldg.
Denver	1535 Broadway
Detroit	10-230 Gen. Motors Bldg.
Indianapolis	202 Indiana Ter. Whse.
Lincoln, Neb.	1425-35 M St.
Los Angeles	912 E. 3rd St.
Milwaukee	1031 Clybourn St.
Minneapolis	1727 Lagoon Ave.
Montreal	415 Canada Cement Bldg.
New Orleans	1230 Hibernia Bank Bldg.
New York	Graybar Bldg.
Omaha	6315 N. 33rd St.
Philadelphia, Pa.	1015 Chestnut St.
Pittsburgh	839 Oliver Bldg.
Rochester, N. Y.	601 Temple Bldg.
Saint Paul	1479 Blair St.
San Francisco	Call Bldg.
Seattle	514 Lloyd Bldg.
Tampa	Polk and Morgan Sts.
Toledo	319 Spitzer Bldg.
Washington	1328 New York Ave. N. W.
York, Pa.	25 N. Duke St.

PACIFIC ELECTRIC
PROVEN EQUIPMENT



HIGH VOLTAGE SECTION—PACIFIC ELECTRIC TESTING LABORATORIES

ALL HIGH VOLTAGE SWITCHING EQUIPMENT DESIGNED AND MANUFACTURED BY THE PACIFIC ELECTRIC MANUFACTURING CORPORATION HAS TO MEET RIGID LABORATORY TESTS IN ORDER TO GIVE THE TRADE

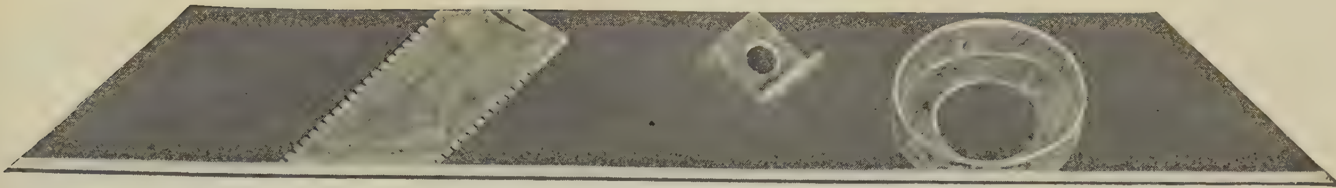
PROVEN EQUIPMENT

Pacific Electric Manufacturing Corp.

5815 THIRD STREET, SAN FRANCISCO, CALIF.

Representatives in Principal Cities


NORMA-HOFFMANN
PRECISION BEARINGS
WHERE capacity for service is the measure of value, prices are to be considered only in so far as they are indicative of performance possibilities. Motors equipped with **"Norma"** Precision Ball Bearings, or with **"Hoffmann"** Precision Roller Bearings, may cost a little more. But their longer life and improved performance return extra earnings which far outweigh any price difference.
HOFFMANN
R-360
NORMA
308
NORMA-HOFFMANN BEARINGS CORPN.—STAMFORD CONN. U.S.A.
N-73



Moulded and stamped with micrometer accuracy in any size and shape

MICANITE, the original pasted mica insulation, is being made in thousands of sizes and shapes, to suit as many varying needs of the electrical industry. For motors, generators, control apparatus, instruments, electrical heaters, radio, etc. Micanite offers outstanding electrical, physical and chemical characteristics.

Micanite possesses high dielectric strength and is readily moulded or stamped to any desired form. An accuracy of 1/1000 of an inch for all dimensions is readily obtained in this age-resisting electrical insulation.

From mine to finishing product—including the making of moulds and designing of dies—every step is controlled by our experts who place the experience of more than 35 years at your service.

Samples of Micanite in many varied shapes are freely offered for your inspection. A letter will receive our immediate attention.

MICA INSULATOR COMPANY

New York: 200 Varick St. Chicago: 542 So. Dearborn St.
Cleveland Pittsburgh Cincinnati San Francisco
Los Angeles Seattle Montreal Toronto, Can.
Works: Schenectady, N. Y. London, England

PERFECT MICANITE INSULATOR REG. U.S. PAT. OFF. *Electrical* INSULATION PERFECT EMPIRE INSULATOR REG. U.S. PAT. OFF.

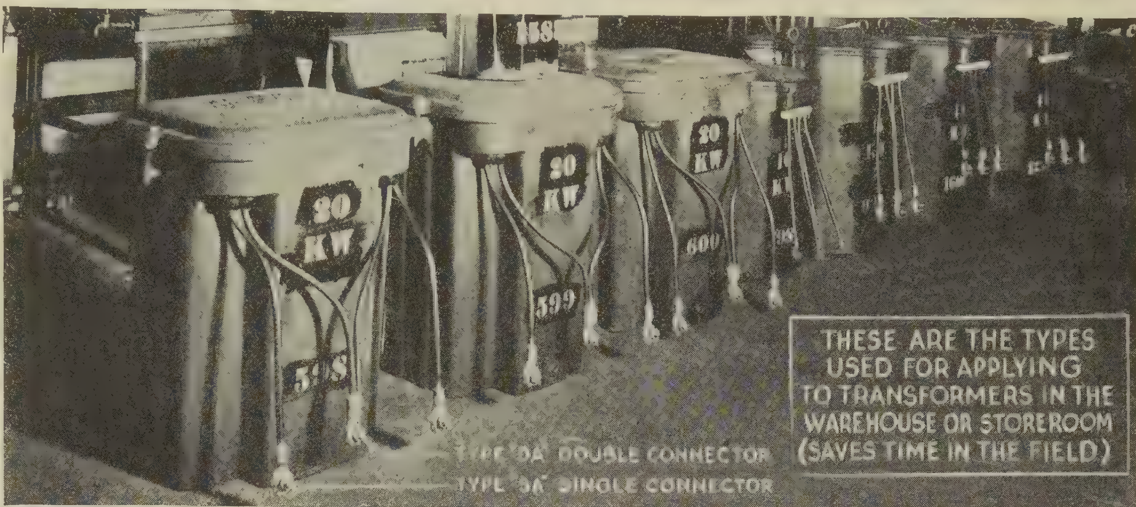
MICA INSULATION OILED CLOTH INSULATION

A NEW LINE OF COMPRESSION CONNECTORS

For Tieing the Leads of Distribution Transformers to Feeder Mains

(*A new idea embodying the utmost in economy and flexibility*)

ASK FOR BULLETIN 38-CB



ASK FOR BULLETIN 38-CB

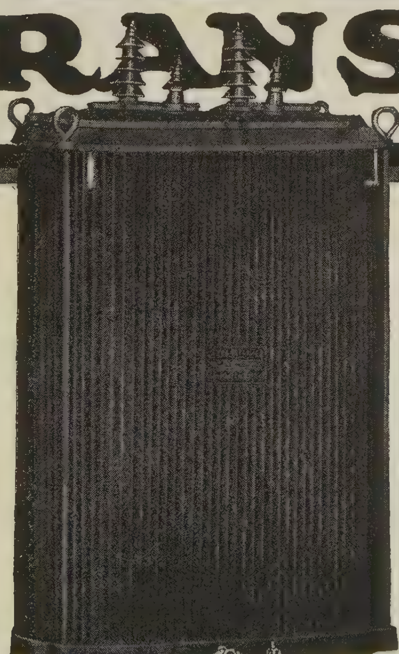
THE DARK HORSE

Delta MAKERS OF UNIT TYPE EQUIPMENT **Star**

DELTA-STAR ELECTRIC COMPANY, 2400 BLOCK, FULTON ST, CHICAGO, ILLINOIS.

THE DARK HORSE

MOLONEY TRANSFORMERS



The many refinements that characterize Moloney Transformers have resulted from long and applied study. Moloney Transformer performance is outstanding because of these betterments in design and construction. Specify Moloney Transformers for Power, Transmission, and Distribution.

MOLONEY ELECTRIC COMPANY
Main Office and Factories: ST. LOUIS, MO.
Sales Offices in Principal Cities

Classified Advertiser's Index for Buyers

Manufacturers and agents for machinery and supplies used in the electrical and allied industries.

Note: For reference to the advertisements see the Alphabetical List of Advertisers on page 51.

AIR COMPRESSORS
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Western Electric Co., All Principal Cities

AMMETER COMPENSATING COILS
Minerallac Electric Co., Chicago

AMMETER, VOLTMETERS
(See INSTRUMENTS, ELECTRICAL)

ANCHORS, GUY
Copperweld Steel Co., Glassport, Pa.
Hubbard & Co., Pittsburgh
Kearney Corp., Jas. R., St. Louis
Matthews Corp., W. N., St. Louis

ARMS FOR STREET LIGHTING
Hubbard & Co., Pittsburgh

BATTERY CHARGING APPARATUS
Electric Specialty Co., Stamford, Conn.
Fansteel Products Co., Inc., North Chicago
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BEARINGS, BALL
New Departure Mfg. Co., The, Bristol, Conn.
Norma-Hoffmann Bearings Corp., Stamford, Conn.
Standard Steel & Bearings, Inc., Plainville, Conn.

BEARINGS, TAPERED ROLLER
Timken Roller Bearing Co., The, Canton, O.

BEARINGS, THRUST & RADIAL
Timken Roller Bearing Co., The, Canton, O.

BLOWERS, PORTABLE
Martindale Electric Co., The, Cleveland

BOXES, FUSE
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., Pittsburgh

BOXES, JUNCTION
Chicago-Jefferson Fuse & Elec. Co., Chicago
G & W Elec. Specialty Co., Chicago
Metropolitan Device Corp., Brooklyn, N. Y.
Standard Underground Cable Co., Pittsburgh

BRACKETS AND PINS, METAL
Hubbard & Co., Pittsburgh

BRUSHES, COMMUTATOR
Carbon
Morganite Brush Co., Inc., L. I. City, N. Y.
National Carbon Co., Inc., Cleveland
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Copper Graphite
Morganite Brush Co., Inc., L. I. City, N. Y.
National Carbon Co., Inc., Cleveland
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BRUSHES, INDUSTRIAL
Hanson-Van Winkle-Munning Co., Matawan, N. J.

BUS BAR FITTINGS
Burndy Engineering Co., Inc., New York
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

BUSHINGS, PORCELAIN
Ohio Brass Co., Mansfield, O.

CABLE ACCESSORIES
Delta Star Electric Co., Chicago
Dossert & Co., New York
G & W Electric Specialty Co., Chicago
General Electric Co., Schenectady
Minerallac Electric Co., Chicago
Standard Underground Cable Co., Pittsburgh
Western Electric Co., All Principal Cities

CABLE RACKS
Hubbard & Co., Pittsburgh
Metropolitan Device Corp., Brooklyn, N. Y.

CABLES
SEE WIRES AND CABLES

CABLEWAYS
American Steel & Wire Co., Chicago
Roebling's Sons Co., John A., Trenton, N. J.

CAMBRIC, VARNISHED
Belden Mfg. Co., Chicago
General Electric Co., Bridgeport, Conn.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CARRIER CURRENT TELEPHONE EQUIPMENT
Western Electric Co., All Principal Cities
Wireless Specialty Apparatus Co., Boston

CIRCUIT BREAKERS
Air—Enclosed
I-T-E Circuit Breaker Co., The, Philadelphia
Roller-Smith Co., New York
Sundh Electric Co., Newark, N. J.
Western Electric Co., All Principal Cities
Oil
Condit Electrical Mfg. Corp., Boston
General Electric Co., Schenectady
Pacific Elec. Mfg. Corp., San Francisco
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CLAMPS, GUY & CABLE
Burndy Engineering Co., Inc., New York
Hubbard & Co., Pittsburgh
Kearney Corp., Jas. R., St. Louis
Matthews Corp., W. N., St. Louis

CLAMPS, HOT LINE
Hubbard & Co., Pittsburgh
Kearney Corp., Jas. R., St. Louis

CLIPS, CABLE
Hubbard & Co., Pittsburgh
Kearney Corp., Jas. R., St. Louis

CLOCKS
Cramer & Co., Inc., R. W., New York
Sangamo Elec. Co., Springfield, Ill.

COILS, CHOKE
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Kearney Corp., Jas. R., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COILS, MAGNET
Belden Mfg. Co., Chicago
Dudlo Mfg. Corp., Ft. Wayne, Ind.
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COMMUTATOR SEGMENTS AND RINGS
Mica Insulator Co., New York

COMMUTATOR GRINDING AND TURNING TOOLS
Martindale Electric Co., The, Cleveland

COMMUTATOR SLOTTERS AND SAWS
Martindale Electric Co., The, Cleveland

COMMUTATOR STONES
Martindale Electric Co., The, Cleveland

CONDENSATION PRODUCTS
Bakelite Corporation, New York

CONDENSERS, COUPLING
For Carrier Current Telephone
Wireless Specialty Apparatus Co., Boston

CONDENSERS, RADIO
General Radio Co., Cambridge, Mass.
Sangamo Elec. Co., Springfield, Ill.
Wireless Specialty Apparatus Co., Boston

CONDENSERS, STEAM
Allis-Chalmers Mfg. Co., Milwaukee
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONDUIT, UNDERGROUND FIBRE
Western Electric Co., All Principal Cities

CONNECTORS, SOLDERLESS
Dossert & Co., New York
Kearney Corp., Jas. R., St. Louis
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONNECTORS AND TERMINALS
Belden Mfg. Co., Chicago
Burke Electric Co., Erie, Pa.
Burndy Engineering Co., Inc., New York
Dossert & Co., New York
G & W Electric Specialty Co., Chicago
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONTACTS, TUNGSTEN
Fansteel Products Co., Inc., North Chicago
General Electric Co., Schenectady

CONTROLLERS
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Sundh Electric Co., Newark, N. J.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

CONVERTERS—SYNCHRONOUS
Allis-Chalmers Mfg. Co., Milwaukee
Electric Specialty Co., Stamford, Conn.
Wagner Electric Corp., St. Louis
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

COPPER CLAD WIRE
Belden Mfg. Co., Chicago
Standard Underground Cable Co., Pittsburgh
Western Electric Co., All Principal Cities

COPPERWELD WIRE
Copperweld Steel Co., Glassport, Pa.

CROSS ARMS, STEEL
Hubbard & Co., Pittsburgh

CUT-OUTS
Condit Electrical Mfg. Corp., S. Boston
General Electric Co., Schenectady
G & W Electric Specialty Co., Chicago
Kearney Corp., Jas. R., St. Louis
Metropolitan Device Corp., Brooklyn, N. Y.
Wagner Electric Corp., St. Louis
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

DRAWING INSTRUMENTS
Cramer & Co., Inc., R. W., New York

DYNAMOS
(See GENERATORS AND MOTORS)

DYNAMOTORS
Burke Electric Co., Erie, Pa.
Electric Specialty Co., Stamford, Conn.

ELECTRIFICATION SUPPLIES, STEAM ROAD
General Electric Co., Schenectady
Ohio Brass Co., Mansfield, Ohio
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

ELECTROPLATING EQUIPMENTS, COMPLETE
Hanson-Van Winkle-Munning Co., Matawan, N. J.

ENGINEERS, CONSULTING AND CONTRACTING
(See PROFESSIONAL ENGINEERING DIRECTORY)

ENGINES
Gas & Gasoline
Allis-Chalmers Mfg. Co., Milwaukee
Oil
Allis-Chalmers Mfg. Co., Milwaukee
Steam
Allis-Chalmers Mfg. Co., Milwaukee

FANS, MOTOR
Century Electric Co., St. Louis
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FARM LIGHTING GENERATORS
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FIRE ALARM SYSTEMS
American Fire Protection Bureau, Inc., New York

FIRE EXTINGUISHING APPARATUS
Walter Kidde & Co., Inc., New York

FLOW METERS
General Electric Co., Schenectady

FURNACES, ELECTRIC
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

FUSES
Enclosed Refillable
Chicago-Jefferson Fuse & Elec. Co., Chicago
General Electric Co., Schenectady
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Classified Advertiser's Index for Buyers—*Continued*

Classified Advertiser's Index for Buyers—*Continued*

ROPE, WIRE
- American Steel & Wire Co., Chicago
- Roebling's Sons Co., John A., Trenton, N. J.

SEARCHLIGHTS
- General Electric Co., Schenectady
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SLEEVE TWISTERS
- Kearney Corp., Jas. R., St. Louis

SOCKETS AND RECEPTACLES
- General Electric Co., Schenectady
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SOLENOIDS
- Belden Mfg. Co., Chicago
- Dudlo Mfg. Co., Ft. Wayne, Ind.
- Electric Controller & Mfg. Co., Cleveland
- General Electric Co., Schenectady
- Sundh Electric Co., Newark, N. J.
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SPRINGS
- American Steel & Wire Co., Chicago

STARTERS, MOTORS
- Condit Electrical Mfg. Corp., Boston
- Electric Controller & Mfg. Co., Cleveland
- General Electric Co., Schenectady
- Sundh Electric Co., Newark, N. J.
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

STEEL, ELECTRIC FURNACE
- Timken Roller Bearing Co., The, Canton, O.

STEEL, SPECIAL ANALYSIS
- Timken Roller Bearing Co., The, Canton, O.

STOKERS, MECHANICAL
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SUB-STATIONS
- General Electric Co., Schenectady
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHBOARDS
- Allis-Chalmers Mfg. Co., Milwaukee
- Condit Electrical Mfg. Corp., Boston
- General Electric Co., Schenectady
- Metropolitan Device Corp., Brooklyn, N. Y.
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

SWITCHES

Automatic Time
- Cramer & Co., Inc., R. W., New York
- General Electric Co., Schenectady
- Minerallac Electric Co., Chicago
- Sundh Electric Co., Newark, N. J.
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Disconnecting
- Burke Electric Co., Erie, Pa.
- Condit Electrical Mfg. Corp., Boston
- Delta-Star Electric Co., Chicago
- General Electric Co., Schenectady
- Kearney Corp., Jas. R., St. Louis
- Matthews Corp., W. N., St. Louis
- Pacific Elec. Mfg. Corp., San Francisco
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Fuse
- General Electric Co., Schenectady
- Kearney Corp., Jas. R., St. Louis
- Matthews Corp., W. N., St. Louis
- Metropolitan Device Corp., Brooklyn, N. Y.

Knife
- Condit Electrical Mfg. Corp., Boston
- Cramer & Co., Inc., R. W., New York
- Electric Controller & Mfg. Co., Cleveland
- General Electric Co., Schenectady
- Matthews Corp., W. N., St. Louis
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Oil
- Condit Electrical Mfg. Corp., Boston
- General Electric Co., Schenectady
- Pacific Elec. Mfg. Corp., San Francisco
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Remote Control
- Condit Electrical Mfg. Corp., Boston
- Cramer & Co., Inc., R. W., New York
- General Electric Co., Schenectady
- Sangamo Elec. Co., Springfield, Ill.
- Sundh Electric Co., Newark, N. J.
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TANTALUM
- Fansteel Products Co., Inc., North Chicago

TELEGRAPH APPARATUS
- Western Electric Co., All Principal Cities

TELEPHONE CONNECTORS
- Kearney Corp., Jas. R., St. Louis

TELEPHONE EQUIPMENT
- Western Electric Co., All Principal Cities

TESTING LABORATORIES
- Electrical Testing Labs., New York

TOWERS, TRANSMISSION
- Western Electric Co., All Principal Cities

TRANSFORMERS
- Allis-Chalmers Mfg. Co., Milwaukee
- American Transformer Co., Newark, N. J.
- Chicago-Jefferson Fuse & Elec. Co., Chicago
- Duncan Elec. Mfg. Co., Lafayette, Ind.
- Electric Service Co., Cincinnati
- Ferranti, Ltd., Hollinwood, England
- Ferranti, Inc., New York
- Ferranti Electric, Ltd., Toronto, Ont.
- General Electric Co., Schenectady
- Kuhlman Electric Co., Bay City, Mich.
- Moloney Electric Co., St. Louis
- Sangamo Elec. Co., Springfield, Ill.
- Wagner Electric Corp., St. Louis
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Factory
- American Transformer Co., Newark, N. J.
- Kuhlman Electric Co., Bay City, Mich.
- Moloney Electric Co., St. Louis
- Wagner Electric Corp., St. Louis
- Western Electric Co., All Principal Cities

Furnace
- Allis-Chalmers Mfg. Co., Milwaukee
- American Transformer Co., Newark, N. J.
- Moloney Electric Co., St. Louis
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

Metering
- American Transformer Co., Newark, N. J.
- Ferranti, Ltd., Hollinwood, England
- Ferranti, Inc., New York
- Ferranti Electric, Ltd., Toronto, Ont.
- Sangamo Elec. Co., Springfield, Ill.

Radio
- American Transformer Co., Newark, N. J.
- Chicago-Jefferson Fuse & Elec. Co., Chicago
- Ferranti, Ltd., Hollinwood, England
- Ferranti, Inc., New York
- Ferranti Electric, Ltd., Toronto, Ont.

Street Lighting
- Kuhlman Electric Co., Bay City, Mich.
- Western Electric Co., All Principal Cities

TRANSFORMERS, USED
- Electric Service Co., Cincinnati

TROLLEY LINE MATERIALS
- General Electric Co., Schenectady
- Hubbard & Co., Pittsburgh
- Ohio Brass Co., Mansfield, O.
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TUBING, SEAMLESS STEEL
- Timken Roller Bearing Co., The, Canton, O.

TURBINES, HYDRAULIC
- Allis-Chalmers Mfg. Co., Milwaukee

TURBINES, STEAM
- Allis-Chalmers Mfg. Co., Milwaukee
- General Electric Co., Schenectady
- Western Electric Co., All Principal Cities
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

TURBO-GENERATORS
- Allis-Chalmers Mfg. Co., Milwaukee
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

UNDERCUTTERS, COMMUTATOR
- Martindale Electric Co., The, Cleveland

VALVES, BRASS

Gas, Water, Steam
- Ohio Brass Co., Mansfield, O.

VARNISHES, INSULATING
- General Electric Co., Bridgeport, Conn.
- Mica Insulator Co., New York
- Minerallac Electric Co., Chicago
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING MACHINES, ELECTRIC
- General Electric Co., Schenectady
- Lincoln Electric Co., The, Cleveland
- Ohio Brass Co., Mansfield, O.
- Westinghouse Elec. & Mfg. Co., E. Pittsburgh

WELDING WIRES & RODS
- American Steel & Wire Co., Chicago
- Lincoln Electric Co., Cleveland
- Ohio Brass Co., Mansfield, O.

WIRES AND CABLES

Armored Cable
- American Steel & Wire Co., Chicago
- Belden Mfg. Co., Chicago
- General Electric Co., Schenectady
- Kerite Ins. Wire & Cable Co., New York
- Okonite Company, The, Passaic, N. J.
- Roebling's Sons Co., John A., Trenton, N. J.
- Simplex Wire & Cable Co., Boston
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

Asbestos Covered
- American Steel & Wire Co., Chicago
- Belden Mfg. Co., Chicago
- General Electric Co., Schenectady

Automotive
- American Steel & Wire Co., Chicago
- Belden Mfg. Co., Chicago
- General Electric Co., Schenectady
- Kerite Ins. Wire & Cable Co., New York
- Roebling's Sons Co., John A., Trenton, N. J.
- Simplex Wire & Cable Co., Boston
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

Bare Copper
- American Steel & Wire Co., Chicago
- Anaconda Copper Mining Co., Chicago
- Belden Mfg. Co., Chicago
- Roebling's Sons Co., John A., Trenton, N. J.
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

Copper Clad
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

Copperweld
- Copperweld Steel Co., Glassport, Pa.

Flexible Cord
- American Steel & Wire Co., Chicago
- Belden Mfg. Co., Chicago
- General Electric Co., Schenectady
- Okonite Company, The, Passaic, N. J.
- Roebling's Sons Co., John A., Trenton, N. J.
- Simplex Wire & Cable Co., Boston
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

Heavy Duty Cord
- American Steel & Wire Co., Chicago
- Belden Mfg. Co., Chicago
- Okonite Company, The, Passaic, N. J.
- Simplex Wire & Cable Co., Boston

Fuse
- American Steel & Wire Co., Chicago
- General Electric Co., Schenectady
- Roebling's Sons Co., John A., Trenton, N. J.
- Western Electric Co., All Principal Cities

Lead Covered (Paper and Varnished cambric Insulated)
- American Steel & Wire Co., Chicago
- Anaconda Copper Mining Co., Chicago
- General Electric Co., Schenectady
- Kerite Ins. Wire & Cable Co., New York
- Okonite Company, The, Passaic, N. J.
- Okonite-Callender Cable Co., The, Inc., Passaic, N. J.
- Roebling's Sons Co., John A., Trenton, N. J.
- Simplex Wire & Cable Co., Boston
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

Magnet
- American Steel & Wire Co., Chicago
- Belden Mfg. Co., Chicago
- Dudlo Mfg. Corp., Fort Wayne, Ind.
- General Electric Co., Schenectady
- Maring Wire Co., Muskegon, Mich.
- Roebling's Sons Co., John A., Trenton, N. J.
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

Rubber Insulated
- American Steel & Wire Co., Chicago
- Belden Mfg. Co., Chicago
- General Electric Co., Schenectady
- Kerite Ins. Wire & Cable Co., New York
- Okonite Company, The, Passaic, N. J.
- Roebling's Sons Co., John A., Trenton, N. J.
- Simplex Wire & Cable Co., Boston
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

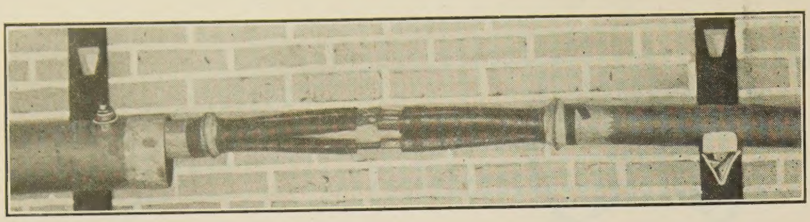
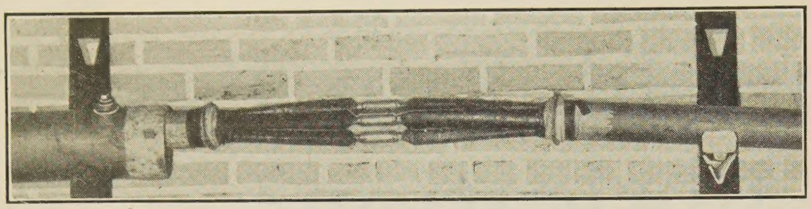
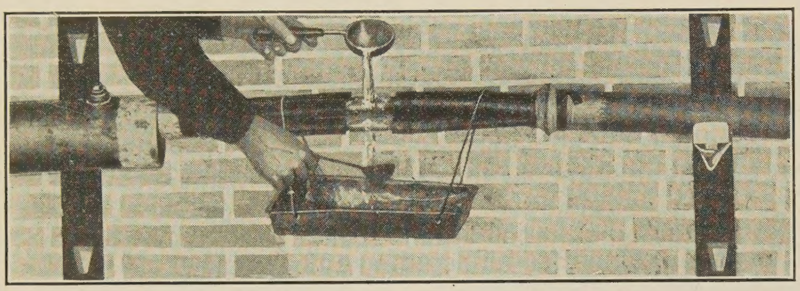
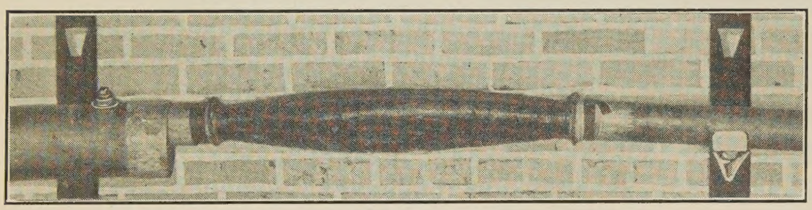
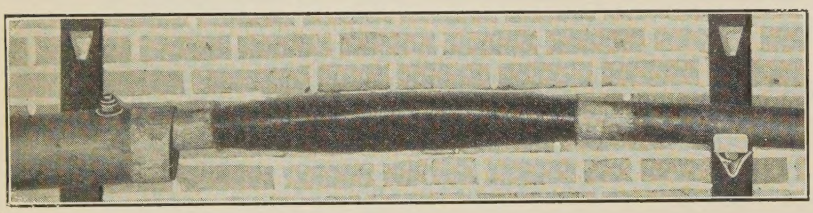
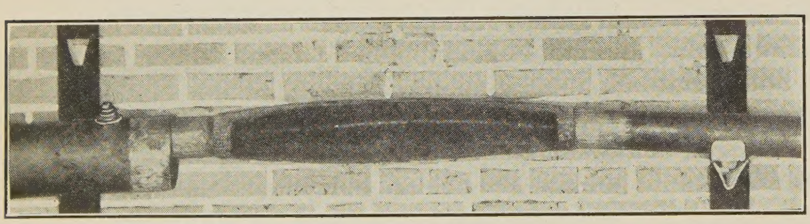
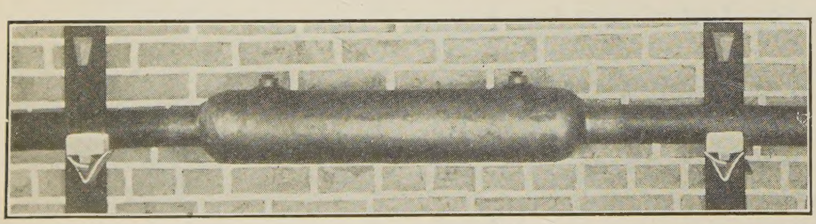
Tree Wire
- Okonite Company, The, Passaic, N. J.
- Simplex Wire & Cable Co., Boston

Trolley
- American Steel & Wire Co., Chicago
- Anaconda Copper Mining Co., Chicago
- Copperweld Steel Co., Glassport, Pa.
- Roebling's Sons Co., John A., Trenton, N. J.
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

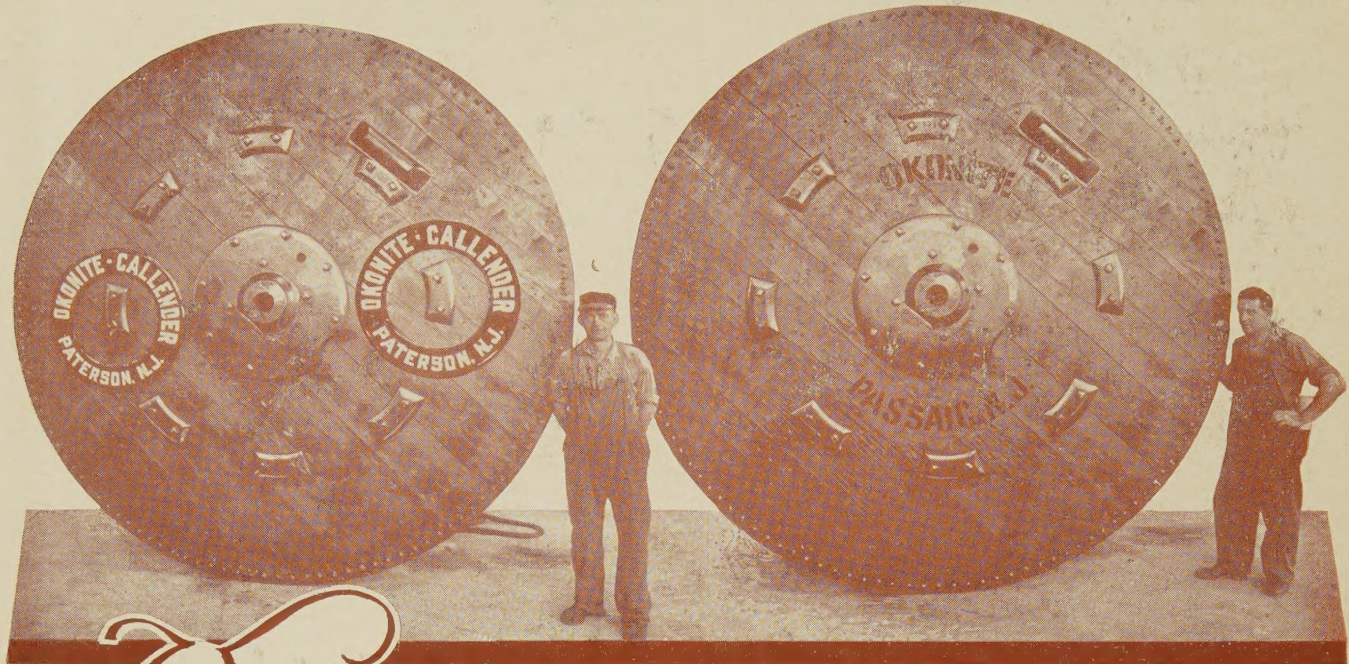
Weatherproof
- American Steel & Wire Co., Chicago
- Anaconda Copper Mining Co., Chicago
- Copperweld Steel Co., Glassport, Pa.
- General Electric Co., Schenectady
- Kerite Ins. Wire & Cable Co., New York
- Okonite Company, The, Passaic, N. J.
- Roebling's Sons Co., John A., Trenton, N. J.
- Simplex Wire & Cable Co., Boston
- Standard Underground Cable Co., Pittsburgh
- Western Electric Co., All Principal Cities

ALPHABETICAL LIST OF ADVERTISERS

(For classified list of Advertisers see pages 44, 46 and 48)

SUBMARINE
POWER CABLE



Where Quality must be Certain

An important specialty of The Okonite Company and The Okonite-Callender Cable Company, Inc., is the design and manufacture of Submarine Power Cables.

Our many years of practical experience have emphasized the extreme care necessary in the fabrication of Submarine Power Cables. The very character of these installations calls for implicit confidence in both the integrity and ability of the manufacturer. Submerged beyond inspection and most inaccessible to fault location and repairs, underwater cables must perform faithfully.

The best assurance of reliable performance is the use of submarine cable that successfully embodies expert design, skillful technique, materials of the highest quality, and the closest supervision throughout manufacture.

Inquiries are invited and we are always glad to be consulted in the planning of submarine power cable installations.

THE OKONITE COMPANY

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U. S. Air Corps Standard DeHaviland 4's — U. S. Airship RS-1 — U. S. Army Curtiss Plane used in Nicaragua

Lindbergh's New Ryan Monoplane — Chicago-San Francisco Mail Plane

A Tribute to Belden Quality

PERHAPS the supreme test of any equipment is airplane service where failure of even the most insignificant part frequently means disaster.

In airplane service vibrations, sudden changes in temperature, and all manner of stresses and strains impose upon electrical cable the severest possible duty.

It is significant that Belden Airplane Wires and Cables have been used on nearly every American plane that has achieved great renown. A few of these famous planes are shown in the illustration.

The accurate manufacturing practices which have made Belden Wires and Cables suitable for exacting airplane service guarantee a uniformly high quality in other Belden Materials.

Write for complete information covering Belden Products in which you are interested.

Belden Manufacturing Company

2316-B South Western Avenue **Chicago, Illinois**

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Automotive Wires and Cables

Airplane Assemblies

Radio Wires, Cords and Cables

Rubber Covered Wires

Armored Cables

Flexible Armature Wires

Motor Lead Wires

Braided and Stranded Copper Cables

Cotton Sleeving

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